GENERAL QUALITY ASSURANCE PROJECT PLAN

(QAPP)

Version 1.0

Previous Versions:
NA

October 2010

Prepared by:
Whatcom Conservation District

Whatcom CONSERVATION DISTRICT

Quality Assurance Project Plan

for

Project: Protecting Puget Sound Watersheds from Agricultural Pollution Using a Progressive Manure Application Risk Management (ARM) System

TITLE AND APPROVAL SHEET

Whatcom Conservation District

July 1, 2010

The following Quality Assurance Project Plan (QAPP) has been reviewed by the following officials and is herby recommended for approval.

_____ Date:_____
George Boggs, Executive Director, Whatcom Conservation District

_____ Date:_____
Nichole M. Embertson, Ph.D., Project Manager, Whatcom Conservation District

_____ Date:_____
Jill Gable, Grant Program Office, Project Manager, EPA R10

_____ Date:_____
Ginna Grepo-Grove, Quality Assurance Manager, EPA R10

_____ Date:_____
Other

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3. DISTRIBUTION LIST

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4. PROJECT/TASK ORGANIZATION

The following section describes the individuals and organizations involved in the project and their primary roles.

4.1. Roles and Responsibilities

The Whatcom Conservation District is responsible for the development, implementation, and monitoring of the ARM project. The granting agency, US EPA Region 10, is responsible for the successful oversight and support for the ARM project. Responsibilities of each individual or agency are as follows.

4.1.1. Whatcom Conservation District

Nichole M. Embertson, Project Manager & Lead Scientist, has an M.S. and Ph.D. in Animal science with a specialty in Environmental Management and will act as Project Manager and lead scientist on the project for WCD. Nichole will be overseeing the scientific and collaborative tasks of the project including ARM creation and installment, sampling methodologies, statistical analysis, outreach, and maintenance of the approved QAPP.

Dawn Bekenyi, Administrative Assistant, will be responsible for financial and administrative record-keeping tasks associated with this proposal, as well as administration of the QA project plan.

George Boggs, Executive Director, has a B.S. in Agronomy and a J.D. in Law and will provide direct oversight to District staff and direct communication with regulatory agencies to ensure timely completion of the project tasks within budget.

Chris Clark, Engineer in Training, has a BS in Biological Systems Engineering with an emphasis in agricultural, soil and water engineering and will participate as a technical resource and engineer for the project.

Andrew Phay, IT Specialist, has been the GIS Technician for the WCD for seven years, since completing a B.S. degree in Environmental Planning with a minor in GIS Studies and will be providing all GIS mapping services, new technology development, and database activities.

4.1.2. US EPA Region 10

Ginna Grepo-Grove, ~~Project~~ Regional Quality Assurance Manager

Jill Gable, Grant Program Officer

Karma Anderson, Project Technical Monitor

Krista Mendelman, Program Coordinator

4.1.3. Project Partners

A Farmer Group and a Partner Group will be assembled whose task will be to offer feedback and policy assessment of the system. Representatives from each of the following agencies have offered in-kind time donations to participate in various aspects of the project.

Local Dairy Farmers – Provide test farms and feedback on ARM tools and results.

Washington Dairy Federation – Help support efforts within the dairy community and provide contacts and communication outlets (i.e., meetings, newsletters, mails, etc.).

Washington Department of Agriculture (WSDA) – Work in close partnership with ARM enforcement and support.

Department of Ecology (DOE) – Collaborate on "Index of Process Condition" for agricultural lands in Whatcom County.

Natural Resource Conservation Service (NRCS) – Work collaboratively to create and initiate new BMPs, incentive programs, and dissemination of ARM system.

Agriculture and Agri-Food Canada– Work with Shabtai Bittman on air quality monitoring and air quality risk section of ARM worksheet.

Western Washington University – Water sampling advisory and field sampling help.

Lummi Nation – Provide County wide water quality data (current and historical).

Washington Conservation Commission – Partner with sister Districts to implement ARM system on a State wide scale.

EPA – Work with our partners at EPA to integrate ARM system into applicable tools and policy.

Other advisory partners (offer feedback and support of project efforts): Portage Bay Shellfish Protection District, Ag Advisory Council, Farm Friends, Whatcom County Public Works, Drayton Harbor Shellfish Protection District Advisory Committee

4.1.4. Project Contractors

The project will utilize outside contractors for certain aspects of the project including laboratory analysis and web design. These individuals are identified within the QAPP (web designer TBA after bid process).

4.2. Project Organizational Chart

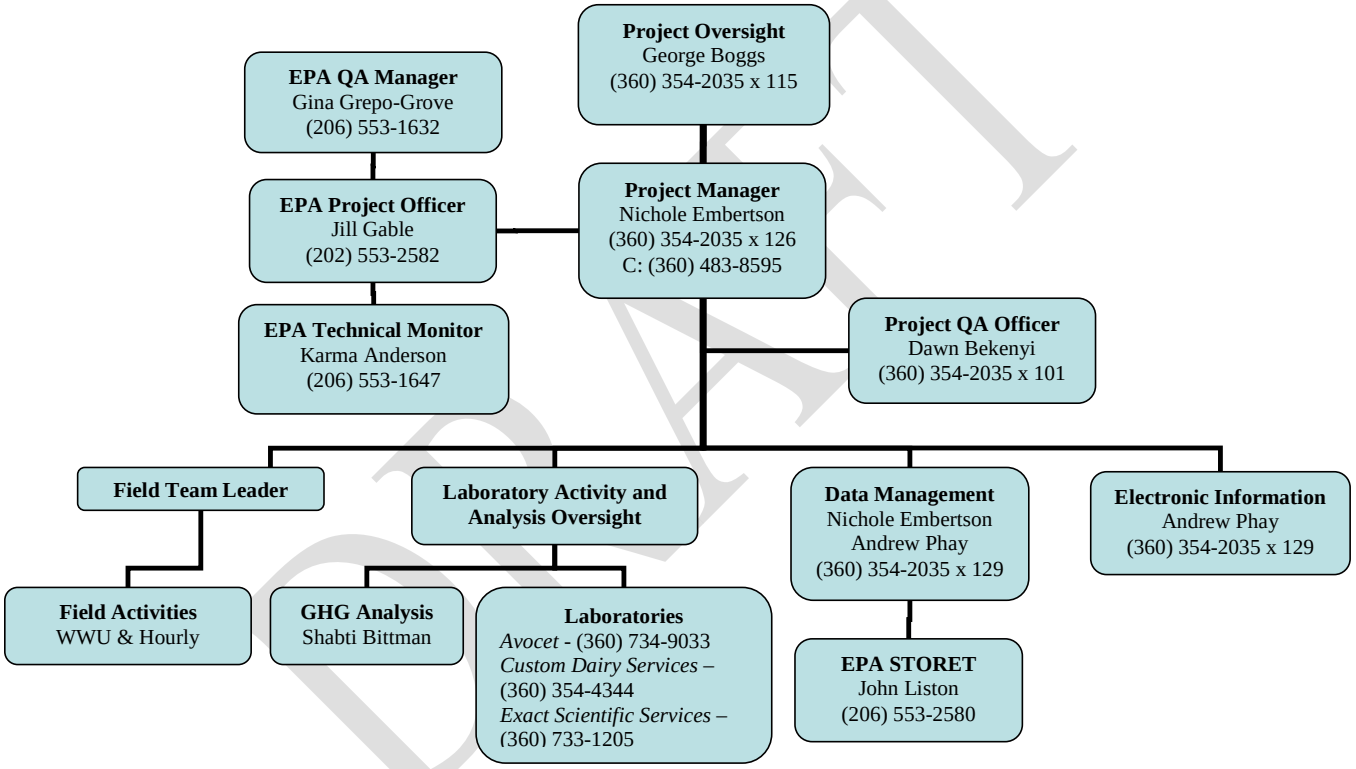

Figure 4.1. Project organizational chart showing primary individuals and organizations participating in the project.

5. PROBLEM DEFINITION/BACKGROUND

Commented [j1]: There are several areas that need the sources cited. When we spoke you mentioned you are planning to or have already added those in.

5.1. Area of Study

This project will be addressing two adjacent watersheds located in western Whatcom County, Washington: the Nooksack and the Strait of Georgia. These two watersheds encompass 1,687 mi^2 bordered by the Cascade Mountain Range to the east, Canada to the north, and the Pacific Ocean to the east. Within these two main watersheds are smaller watershed areas including the Lower Nooksack Sub-basin (Nooksack), as well as Drayton Harbor, Birch Bay, and Lummi Bay (Strait of Georgia). Each of these watersheds has surface waters that flow from inland areas to the marine, affecting the Puget Sound, as well as various resources, communities, and industries along the way. Collectively, the health of the two watersheds is under great pressure from land use changes and agricultural uses.

5.2. Problem Background

The combined Nooksack and Strait of Georgia watershed areas outlined above are under both land use change and environmental resource pollution strain. The primary resources and industries affected by these pressures are agriculture (primarily dairy), shellfish and salmonid fish populations, as well as the water and air quality that supports these industries and the populations that surround them.

Due to land use changes and population pressures, the Lower Nooksack Sub-basin has a heavily impacted floodplain, high nitrates in groundwater, and poor riparian conditions throughout the Nooksack River and most of its tributaries. Dept. of Ecology's (DOE) current 303(d) list of impaired waters shows that there are 34 stream and river segments in the watershed that are above acceptable limits for, among other things, fecal coliform, the primary source of which is estimated to be the improper application of manure to agricultural fields. Poor water quality, coupled with the loss of stream habitat, has contributed to the noticeable decrease in annual salmon populations returning to the watershed. This impacts Tribal communities as well as local industries, and threatens the future health of the salmon population in the area. Additionally, compared to other rivers in the Puget Sound region, the Nooksack River near its mouth at Portage Bay has among the highest levels of nitrogen, phosphorous, and suspended solids, which affects both upstream fish and shellfish populations. This is due in part to the large number of agricultural operations located upstream in the Nooksack Sub-basin.

In addition to water quality, air quality is also adversely impacted by growth and improper land use. Urbanization leads to an increase in fuel use and urban emissions, which when combined with natural VOC production from vegetation and agricultural ammonia emissions (which are not currently addressed nor regulated), can increase the production of fine particulate matter (PM2.5) and smog. This fine PM can adversely affect human health and deposit via rain or dry deposition on inland waterways and on the Sound, increasing nutrient loads and decreasing water quality. A reduction in agricultural ammonia production, up to half of which comes from field manure application, may aid in reducing smog and PM deposition within the Puget Sound airshed. Urbanization can also increase greenhouse gas production and subsequent climate change issues in the region via the conversion of productive agricultural and forested lands to impervious urban surfaces, which decreases vegetative carbon sequestration. Climate change

coupled with population growth has put a strain on already scarce and diminishing water resources available for municipal and agriculture irrigation use in the watershed.

In Whatcom County, as in many other counties in the State, impacted and poorly managed agriculture (in particular, manure application by dairies) has repeatedly been identified as a leading contributor to air and water pollution in the watersheds. Therefore, the most productive way to address many of the water and air pollution issues within the watershed and contribute to the larger interconnected effort of protection of the watershed is to target the proper application of manure to farm fields. Improper application of manure can lead to runoff, which can cause low dissolved oxygen, algae production, high nitrates, and pathogens in water. Since dairies are the largest producers of manure and manure application in the watershed, improvements in field application methods and timing are necessary in order to protect important watershed and air resources from further negative impacts. However, current guidelines do not promote better application practices, and in fact, threaten the health of the Sound even further by pushing application under risky conditions and times of the year (October and March) without proper assessment of weather or field conditions. Currently, the ceasing of manure application in the fall is Oct. 1st in the floodplain, and Oct. 31st everywhere else; and the start date of applciation in the spring is T-Sum200 (200 cumulative celcius temperature units after Jan 1) or February 15, whichever is sooner. These application dates are problematic because they do not require farmers to assess their unique field conditions and practices; prevent application at times when it may be more faviorable; do not promote planning of dry season application; and they allow farmers to apply during unfavorable conditions contributing to both surface and groundwater pollution. The dates are estimated values chosen to coincide with the start of flood season and plant growth, but in a changing climate, are not always correct. Instead, they encourage application in the fall when uptake is diminishing and rainfall is high, and allows spring application on a date that sometimes encourages application during wet conditions and when water tables are high. We can see a correlation between late season manure application, fall rainfall events and most shellfish bed closures and salmon migration events. Additionally, we see an increase in dry season (May-Sept) episodic air pollution events, partially contributed by ammonia from manure application during unfavorable weather conditions. This is an issue that has not been addressed in the area. Simply increasing buffer and manure setback widths is not a substitute for precision application and will not correct the root of the problem.

Of the 12 Washington State Puget Sound Districts, Whatcom County has the greatest concentration of dairy cows, with 53% of the total, or over 40,000 animals, within its boundaries, most (~75%) of which are concentrated in the 310 mi^2 of the Nooksack and Strait of Georgia watersheds. Although the number of dairy farms in Whatcom has decrease by half in the last 10 years, the number of milk cows has only been reduced by about 30%, putting increased strain on available land and water resources available. Dairying has been a pillar industry in the area for generations and is an intricate part of the community life. The dairy operations in the region have the ability to contribute in a positive way back to the environment and community by providing wildlife habitat, stream protection, carbon sequestration, and economic community stimulus. However, population growth pressures, environmental restrictions, and poor relations with environmental partners have led dairies to be identified as one of the primary contributors to water and air pollution issues in the watershed. The majority of these pollution events arise during or after the application of manure to farm fields, with water quality pollution being highest in the wet season (Oct-April) and air quality in the dry season (May-Sept). It is this area

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that needs to be addressed as a means of improving the health of the watershed before growth exacerbates the issues at hand.

It is the overall objective of this project to create an Application Risk Management (ARM) system that will reduce the risk of manure induced pollution within the watershed and implement a system to help farmers evaluate their application risks and monitor their progress. The ARM system will supplant the current ridged application dates (Oct 31 and T-Sum200), and revise manure application setback distances and buffers to adjust with changing field and weather conditions. Instead, farmers will have to cease fall application in September and have limited early season application, which has been shown to be beneficial to plant growth and nutrient uptake during the spring. This will prevent application in risky times and support application at times when it is appropriate and poses the least threat to resources. When properly implemented, the system will be successful in contributing to the goals of our local WRIA 1 partners, as well as EPA national goals for Puget Sound, by improving the health of 37,000 acres of impacted farmland, 350 miles of impaired waterways, and 7,000 acres of shellfish growing areas. It will also address the priorities of the Puget Sound Action Agenda by reducing a source of water pollution in the watershed and protecting from it future pollution with education and good management tools. The impact of these achievements should help keep shellfish beds open during high risk seasons, reopen prohibited areas, reduce fish barring stream pollution to increase the health of the salmon, and sustain agriculture and the rural lifestyle in a growing community. Since water and air act in a symbiotic relationship, typically trading impacts like a see-saw, the ARM system will be addressing the air quality and climate change within the 300 mi^2 airshed to make sure we are not trading one problem for another, but rather addressing both equally. This addresses EPAs clean air and clean water priorities by eliminating sources of airborne deposition of nutrients (nitrogen) on waterways.

Since the other dairy producing districts in the Puget Sound share our same environmental issues, this system will be widely shared with others to decrease the impacts of agricultural pollution beyond Whatcom County. It is our intention to adapt and share this system with other Conservation Districts and livestock management organizations in Washington State and the Region, as well as our partners in Canada, all who share some or all of the same resource concerns as we do. The ARM system idea has been met with positive response from farmers, regulators, Tribes, and community members. Additionally, OnePlan software developers have expressed interest in its integration into their nutrient planning software programs, and it can also be used with other tools like Manure Management Planner (MMP). Overall, the ARM system should provide a way for farmers to evaluate their air and water pollution risks associated with manure application at any time of the year and apply with greater precision, flexibility, and responsibility, which should increase yields, decrease environmental pollution, and restore a sense of environmental stewardship. To date, there are no similar application management systems in use.

5.3. Project Objectives

1. Conduct a series of land surveys to identify areas within the watershed that are at high risk for ground and surface water pollution, as well as classify low risk areas that are best suited for agricultural land use.

2. Send out a survey to producers so that we may gain a better understanding of current environmental practices, constraints to BMP adoption, knowledge base, and effective communication routes.
3. Develop and scientifically evaluate an interactive Application Risk Management (ARM) System that minimizes nutrient and pathogen pollution events to air, surface and ground water using a combination of field risk analysis, pre-application field assessment, education, risk alert tools, and accountability.
4. Collaborate with project partners and farmer groups to open discussion and test ARM tools.
5. Assess current NRCS vegetative practices and manure application setback guidelines for seasonal effectiveness at managing potential runoff from fields.
6. Develop educational and informational materials that will be available to all producers and custom manure applicators including a workshop, webpage, risk alerts, newsletter, and email/fax information system. These materials will help manure applicators learn about the program, get help, and keep informed on times when application is optimal or prohibited.
7. Integrate the ARM system into planning software and Nutrient Management Plans at a County and State wide level.

The long-term outcome of this project is the implementation of a more comprehensive and effective manure application management system that will reduce runoff and air pollution events, decrease the fecal coliform and nutrient loading into the Nooksack and Strait of Georgia Watersheds to increase the vitality of freshwater fish and marine shellfish areas, increase surface and groundwater quality, and improve air resources for the community. Additionally, by giving farmers a more active and responsible role in the management of their land, we hope to reinvigorate the sense of environmental stewardship that was once prevalent in this area and reconnect farming to the community.

6. PROJECT DESCRIPTION

This study will develop an innovative manure Application Risk Management (ARM) system that will decrease the transport of nutrients and fecal coliform to environmental resources such as surface water, groundwater, and air, and increase agronomic application and accountability. The study will be conducted in 4 phases, 1) Assessment, 2) Development, 3) Implementation and Monitoring, and 4) Evaluation, Adaptation, and Outreach over four years.

Commented [j6]: This may be a good place to discuss future annual addendums (or as needed/at completion of each phase) with project updates and developments, as some important details will be decided in the initial phases of the project. Later in the QAPP when you speak of areas which are not yet final, you can cite back to this section for reference to the ongoing updates. This QAPP will essentially be a living document throughout the life of the grant due to the dynamic nature of the project.

6.1. Phase 1: Assessment

Phase 1 is the characterization and assessment of the watershed as it relates to agricultural practices and potential environmental impacts. Using a risk rating system based on 15+ different soil and field characteristics (i.e., soil type, permeability rate, water table, distance to surface water, slope, etc.), watershed and field maps will be created for runoff, leaching, and air pollution risk potential. Specifically, "hot spots" will be identified within the watershed that will benefit most from a targeted approach for risk management. This land survey will help locate areas that are best suited for agriculture, aid in land use planning for environmental protection, and help farmers make better land use decisions on crop selection and manure application

Commented [j7]: GIS?

Commented [j8]: Recommend defining, as you did in your response comments.

technologies. This same process will be used on a micro scale with individual farms to assess the risk level associated with manure application to specific farm fields.

To better identify the most effective modes of communication with landowners, producer preferences, appealing incentives, knowledge base, and current practices, a survey will be sent out (mail and web based) to all producers in the watershed areas. The survey will be analyzed for preferences and trends to give us an idea of target areas and information delivery systems.

Phase 1 Deliverables

- Land survey and risk rating index for watersheds.
- Individual land risk evaluations for project farms as they are enrolled in ARM.
- Survey of dairy producers to gain a better understanding of current practices, constraints to mitigation, preferences for manure management, and knowledge base. (Anonymous responses, correct?)
-

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6.2. Phase 2: Development

Phase 2 is the development of the Application Risk Management (ARM) System components to address both water and air quality impacts associated with manure application. The ARM system is based on two main factors, the farm field risk evaluation addresses in Phase 1, and the use of a web based risk management worksheet designed to assist a producer in determining the application risk index for that current time of year.

Prior to application of manure to any field, any time of the year, a producer will have to complete the ARM worksheet, which will evaluate runoff, leaching, and volatilization potential and provide feedback for proper application techniques. The worksheet evaluates pollution potential (i.e., distance to resources, emissions, groundwater recharge, etc.), current field conditions (i.e., ponding/flooding, frozen ground, soil moisture, water table depth, vegetation density and height, buffers, etc.), application method, and current and forecasted weather conditions. All of these parameters, along with soil type and nutrient analysis, will be entered into an interactive worksheet and a pollution risk rating calculated along with practice guidelines and a maximum recommended application amount. If conditions are not optimal for application (i.e. water table too high, significant rain in 3 day forecast, low crop uptake, etc.), the system would tell producers to wait to apply. This complex type of feedback will require the creation of detailed background calculations based on both modeled and field proven values for each of the criteria, as well as comprehensive parameter definitions and feedback responses. The field proven values will be collected in Phase 3 of the project. All of these functions will be integrated into a user-friendly worksheet that will give automatic feedback to input values and log the data for our records and analysis. The worksheet will allow producers to responsibly evaluate each of their fields on a seasonal basis and only apply an appropriate amount of manure to fields that are at low risk for environmental pollution. Once developed, the final worksheet and specifics will be included as an addendum document to the QAPP.

Commented [j9]: Or something along those lines…

To ensure producers have accurately performed the calculations to evaluate their application risks, an accountability system will be implemented where producers will have to submit their analysis sheet to WCD prior to application for approval. This level of "supervision" is vital in order to properly manage and mitigate potential environmental impacts. In order to remain in the

Commented [j10]: Will every worksheet be checked, or a set percentage?

ARM program, producers must follow all guidelines and recommendations set forth If a producer deviates from the system, and applies manure outside of their DNMP protocols, a penalty protocol will be instituted by the appropriate regulatory agency (not WCD).

Commented [j11]: Which agency has the authority to enforce though?

To ensure that we are creating a useful, efficient product, a two tiered technical workgroup will be assembled consisting of a farmer panel and partner workgroup. The group will be anchored by progressive and cooperative dairy producers who are willing to offer constructive criticism of the ARM system and communicate to fellow dairymen. In addition to their individual contributions to project components, input will also be requested of project partners to make sure we are meeting common goals and collaborating in a productive manner. Meetings will be held bi-annually for farmer panel and annually for partners.

In addition to the ARM worksheet, new risk management tools will be developed. These tools include application alerts based on current weather conditions; a webpage with local forecasts, worksheet Q&A, application techniques, vegetative maintenance guide, etc, to provide farmers with information relevant to application and the ARM system; and lastly, a self-update system for farmers to self-update on a yearly basis to adjust application levels when appropriate (i.e., if crops, fields, or manure chemistry changes).

Commented [j12]: Sounds great.

Phase 2 Deliverables

- ARM Worksheet.
- An accountability system including an emergency response plan and monitoring and enforcement plan.
- Assembly of workgroups including the farmer panel and partner groups.
- Development of ARM tools: application alerts, webpage, self-update system.

6.3. Phase 3: Implementation and Monitoring

The ARM system will be implemented, tested, and monitored for success at dairies within the target watersheds. This Phase will extend over three application seasons. The first year, we will test the ARM system on 5 fields on dairy farms that have already given their commitment to participate in the project and provide feedback. We kept this number to 5 the first year to e~~i~~nsure we can provide a high level of observation, management, guidance, and sample monitoring appraisal in the infancy of the system. Each successive year, we will add new test farms to the project throughout both watersheds. Farms will vary in risk rating and location within the watershed, illustrating the different characteristics of the watershed areas. Every farm that participates in the study will have a Nutrient Management Plan update, as well as detailed mapping of fields, water systems, and identification of sampling locations.

Commented [j13]: What kind of mapping? Via GIS?

To measure the effectiveness of the ARM system, concurrent soil, surface water, soil water, groundwater, forage, manure, and air quality testing will be conducted on selected test fields throughout the year (see table 6.1 for analysis). All sample data will be analyzed using statistical models to evaluate significance (alpha level of 0.05) within test sites and between test and control sites. The information in this QAPP document details the sample procedures and project data management.

Table 6.1. Summary of analyses for each medium sampled

Surface Water	Ground/Soil Water	Air	Soil	Manure	Forage	Meteorological
Laboratory						
Fecal coliform (FC), total-N, TKN, nitrate, total-P	Fecal coliform (FC), total-N, TKN, nitrate, total-P	Nitrous oxide, methane, carbon dioxide	EC, OM, FC, total N, nitrate, total P, pH	EC, OM, C:N, FC, total N, ammonium, nitrate, total P, pH	DM, CP (N), P, nitrate	-
Field Equipment						
Dissolved oxygen, pH, conductivity, temperature, nitrate, ammonium	Dissolved oxygen, pH, temperature, conductivity, nitrate, ammonium, soil moisture	Ammonia	-	-	-	Temp, RH, wind speed, wind direction, pressure, alt., dewpoint, wet bulb temp, precipitation

Commented [j14]: Provide a key for analysis acronyms.

In conjunction, data from current DOE and WRIA 1 stationary monitoring sites will be assessed to provide information on background temperature, FC, and DO levels (as applicable), variability, and pollution spikes to help us locate problem areas and times within our target watersheds. Ambient air quality measurements will also be taken for ammonia and greenhouse gases (nitrous oxide and methane, CO2?). All of these measurements will be used in the validation of the system, tuning of worksheet parameters, and assessment of the watershed.

Commented [j15]: What type of monitioring? Air, GW, SW, ets?

ARM worksheet outputs and subsequent application records will be kept to track the feedback mechanism of the system as well as map the nutrient loading to areas in relation to stream pollution levels, groundwater nitrate levels, and air emission events using GIS software. This will help us revise, adapt, and track the validity of the system, as well as assess the impact of ag-urban growth pressures and possible impacts.

Phase 3 Deliverables

- Identification of test farms, update of DNMPs, field mapping and risk analysis, and implementation of ARM system.
- Implementation, monitoring, assessment, and validation of the ARM system. Where do you discuss what criteria you will use for assessment and validation of the ARM system?
- GIS Mapping of nutrient loading in relation to stream pollution levels and air emission events.
- Analysis of application technologies and characteristics to aid in development of manure application BMPs for water and air pollution reduction.

6.4. Phase 4: Evaluation, Adaptation, and Outreach

A constant evaluation and revision of the ARM system will be conducted as results are obtained and input is received from producers (users) and project partners (evaluators). This will ensure that the system and its tools are user friendly, comprehensive, and successful at achieving the desired watershed protection goals.

To ensure the long-term success of the ARM system, all Nutrient Management Plans created or updated by WCD will include the ARM system. In addition, cost-share incentives will be explored with partners at NRCS to identify sources of funding for farmers implementing the ARM system with more rigorous conservation practices. Additionally, guidelines for manure application dates, setbacks, and restrictions will be revised to reflect our findings and more stringent guidelines. In conjunction, legislation will be explored to support our guidelines and aid in implementation of the ARM system on a larger scale. This endeavor will need to be explored with project partners. Our goal is to adapt the ARM system to all forms of agriculture that apply manure including berry and crop farmers, small farms, hobby farms, mitigation projects, and other livestock (poultry, beef, swine).

A public outreach effort will be initiated to inform and gain support from the public. A workshop, web link, newsletter, email/fax alert system, and development of new technologies will aid in keeping producers and the community involved and informed on the systems success and benefits.

In addition to quarterly reports, the final report will evaluate the system with scientific basis and determine its sustainability and effectiveness at achieving a permanent reduction of pollutants contributed by runoff from agricultural fields.

Phase 4 Deliverables

- Continuous evaluation and adaptation of ARM system based on project results and user feedback.
- Explore cost share incentives, revise manure application dates, explore legislation through partners to incentivize the ARM system, and adapt ARM to include all forms of agriculture the utilize grazing or manure application practices.
- Outreach activities including a newsletter, email list, and workshop to educate users about the ARM system and related environmental issues.
- Quarterly reporting throughout project and final report at conclusion.

6.5. Study Area

The following map shows the area of study. Specific study sites are not identified on this map due to confidentiality issues; however, targeted areas are circled in blue.

Commented [j16]: I understand the reasons for confidentiality. However, is the data FOIA-able? Just something to consider.

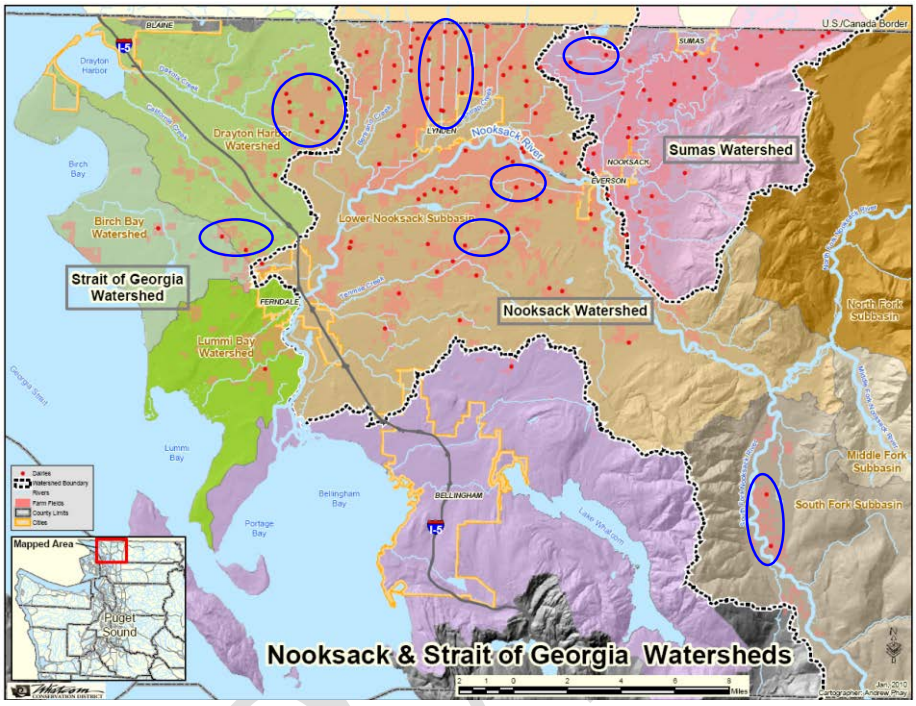

Figure 6.1. Map of study area. Test farms will be located in the Strait of Georgia and Nooksack Watersheds. Red dots depict dairies and pink areas represent the land base associated with those dairies. Blue circles represent areas where test farms will be located in years 1 and 2 of the study.

6.6. Project Timeline

Commented [j17]: Obviously a bit behind schedule at this point…

The following table shows the timeline of major tasks and deliverables to be completed during the project time frame. The dates listed are approximate and may vary depending on other task completion dates, partner availability, weather, and unforeseen circumstances. Project deadlines will adhere to listed dates as best as possible.

Table 6.2. Project timeline

Task	Action	Timeline*
Year 1		
Project start date	Start	July 1, 2010
Equipment purchase	Start	August 1, 2010 - Open
ARM Worksheet development	Start	August 1, 2010 - Open
Enroll test farms (*Year 1 - 10*)	Due	August 15, 2010
QAPP Development and submittal	Due	October 30, 2010
Develop and submit survey to EPA	Due	November 30, 2010
Field equipment installation	Start	October 1, 2010
Begin field sampling	Start	October 1, 2010
Begin data acquisition and analysis	Start	October 1, 2010 - Open

Develop emergency response plan	Start	October 1, 2010
ARM tools development and testing	Start	October 1, 2010 - Open
Quarterly Newsletter (#1)	Due	November 1, 2010
ARM survey assessment maps	Start	November 1, 2010 - Open
Farmer Panel Group Meeting	Due	December 1, 2010
Send out producer survey	Due	December 1, 2010
Bi-annual reporting	Due	January 1, 2011
Partner Group Meeting	Due	February 20, 2011
Quarterly Newsletter (#2)	Due	March 1, 2011
Enroll test farms (*Year 2*)	Due	May 1, 2011
Quarterly Newsletter (#3)	Due	June 1, 2011
Year 2		
Bi-annual reporting	Due	July 1, 2011
Partner Group Meeting	Due	August 1, 2011
Quarterly Newsletter (#4)	Due	September 1, 2011
Quarterly Newsletter (#5)	Due	December 1, 2011
Farmer Panel Group Meeting	Due	December 15, 2011
Bi-annual reporting	Due	January 1, 2012
Quarterly Newsletter (#6)	Due	March 1, 2012
Enroll test farms (*Year 3*)	Due	May 1, 2012
Quarterly Newsletter (#7)	Due	June 1, 2012
Year 3		
Bi-annual reporting	Due	July 1, 2012
Partner Group Meeting	Due	August 1, 2012
Quarterly Newsletter (#8)	Due	September 1, 2012
Quarterly Newsletter (#9)	Due	December 1, 2012
Farmer Panel Group Meeting	Due	December 15, 2012
Bi-annual reporting	Due	January 1, 2013
Quarterly Newsletter (#10)	Due	March 1, 2013
Enroll test farms (*Year 4*)	Due	May 1, 2012
Quarterly Newsletter (#11)	Due	June 1, 2013
Year 4		
Bi-annual reporting	Due	July 1, 2013
Partner Group Meeting	Due	August 1, 2012
Quarterly Newsletter (#12)	Due	September 1, 2013
Quarterly Newsletter (#13)	Due	December 1, 2013
Farmer Panel Group Meeting	Due	December 15, 2013
Bi-annual reporting	Due	January 1, 2014
Finalize and release educational materials	Due	February 1, 2014
Workshop on ARM system	Due	February 1, 2014
Outreach ARM to all partner agencies	Due	February 1, 2014
Quarterly Newsletter (#14)	Due	March 1, 2014
Quarterly Newsletter (#15)	Due	June 1, 2014
Final Report	Due	July 1, 2014

7. QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The EPA outlines a Data Quality Objectives (DQO) process for addressing the specifications needed to support the qualitative and quantitative components of the project as well as the performance or acceptance criteria of the study design. It must be noted that no data are free of error and that some level of uncertainty must be accepted.

This area of the QAPP relates to the data (surface water, groundwater, soil water, soil, manure, forage, and air) that will be collected in the field from test farms. A more detailed breakdown of the acceptance criteria and frequency of QC measurements for both field and lab parameters are located in Section 14.

7.1. Data Quality Objectives

Data Quality Objectives are qualitative and quantitative statements derived from the DQO process outlined in the EPA document: *Guidance for Data Quality Objective Process* (EPA QA/G4). This process outlines the monitoring objectives, defines the appropriate type of data to be collected, and specifies the tolerable levels of decision errors for the monitoring program.

The overall objective of this study is to obtain data that will aid in the characterization and assessment of the environmental impact of manure application to farm fields in relation to parameters set forth by our risk assessment criteria. More specifically, the data quality objectives are to: ~~i~~ensure that the parameters measured during this study will adequately describe nutrient cycling in the system at levels necessary to understand the processes taking place; to insure that sample results are representative of the target watershed at the time of sampling and that the data produced during this study are accurate; and lastly, to reduce the uncertainty associated with manure applied nutrient cycling in the environment (water, air, soil). In order to accomplish this, we have determined that environmental and meteorological data need to be collected based on appropriate sampling and analysis methods. Data collected will be used to establish thresholds for Worksheet assessment parameters, as well as for general system characterization purposes.

Commented [j18]: What RA guidelines and criteria are you following?

7.2. Measurement Performance and Acceptance Criteria

Measurement, performance, and acceptance criteria help maintain data within an acceptable range of uncertainty. In general, we expect a normal distribution for measurement error with decision error limits set at 5% (alpha = 0.05). Additionally, measurement imprecision is established at a 10% coefficient of variation (CV). The quality of the data will be evaluated and controlled to make sure it is maintained within the established measurement criteria listed using principle indicators of precision, bias, accuracy, representativeness, comparability, completeness, and sensitivity. Each of these indicators is detailed below (definitions are adapted from EPA definitions outlined in *EPA QA/G-5*).

7.2.1. Precision

Precision is the measure of agreement among repeated measurements of the same kind, which is represented by the coefficient of variation (CV = 10%). To increase precision and reduce variability between measurements, we will follow accepted/approved methods which are documented by~~set~~ standard operating procedures (SOP) for instrumentation placement and use,

sample collection, sample handling, and analysis. The same analytical instrumentation and methods will be used to make repeated analysis on duplicate samples to ensure precision. Additionally, quality control and duplicate or split field samples will be taken and submitted for precision of sampling handling, preservation, storage, and analytical measurements. Laboratory analysis will be verified for precision by submitting blind replicates to the same laboratory. If the replicate falls outside of the acceptable range of 10% difference between samples, samples will be resubmitted (if duplicates are held in storage) or retaken (If applicable). Any identified areas of sample attainment that have variation outside of the acceptable limits will be reassessed and adapted to reduce variability.

OR: Precision is a measure of mutual agreement among replicated (or between duplicate) or collocated sample measurements of the same analyte. The closer the numerical values of the measurements are to each other, the more precise the measurement. Precision is determined through calculation of analytical and/or total measurement error. See table XX for accuracy criteria which will meet the project DQOs.

Commented [j19]: 10% is pretty tight, especially for non-water matrices. The inherent variability in analytical methods is usually 10-30% minimum, depending on the level of quanitation.

7.2.2. Bias

Bias is the systematic or persistent distortion of a measurement process that consistently causes error in one direction. To avoid sample bias from sample attainment, processing, or analysis, reference methods and SOPs will be followed. To avoid sample bias from analytical field equipment, equipment will be calibrated on a regular basis following manufacture guidelines. To assess laboratory bias, on occasion, duplicate samples will be sent to multiple labs for identical analysis.

Commented [j20]: The base methods are ALWAYS cited in QAPPs, with SOPs referenced and included as documentation of how the methods will be followed. However, for comparibility and project documentation the method must always be cited.

7.2.3. Accuracy

Accuracy is the measure of overall agreement of a measurement to a known value. Accuracy includes both precision and bias errors. To increase accuracy of field equipment, equipment will be calibrated to a known concentration value and reported as percent recovery or percent bias. The laboratory will perform their own QAQC procedures to ensure accuracy of measurement values.

Accuracy is a measure of bias in a measurement system. The closer the value of the measurement is to the true value, the more accurate the measurement. Accuracy is expressed as the percent recovery of the surrogate or spike analyte from a sample or standard. Accuracy is dependent on traceability of instrumentation, standards, samples, and data methodology; blanks; surrogates; reference or spiked samples; performance samples, and equipment calibration. See table XX for accuracy criteria which will meet the project DQOs.

Commented [j21]: This is true. However, the lab must be doing what is required in the analytical method and the project must ensure that the lab's QA/QC meets the project DQIs. Therefore, the quality of the data must be well documented in the QAPP. You cannot just state that the lab will be performing sufficient checks, because that will vary from lab to lab and is not sufficiently defined.

7.2.4. Representativeness

Representativeness is a qualitative term that refers to the degree to which data accurately and precisely represents a quality of the sample population being measured. Ensuring an appropriate sample design and minimum appropriate sample number will aid in appropriately characterizing the population and/or environmental condition being measured. Sample designs and sample attainment times are chosen in such a way to ensure both spatial and temporal representativeness of data. Project farms are selected randomly within the watershed to allow representation of various physical and climatic conditions to be accounted for. A log of field and/or laboratory

conditions will aid in characterizing and identifying any conditions that might affect sample integrity. Representativeness is also evaluated, in part, by examining the chain-of-custody paperwork and verifying that the sample analyses were performed within the holding time.

7.2.5. Comparability

Comparability is a qualitative term that expresses the level of confidence that one data set can be compared to another and be combined for analysis. This applies both to different data sets collected within the current study, as well as data set sets outside of the study. Factors of comparability include sample collection method, handling and storage method, sample preparation and analysis procedures, holding times, stability, and QA protocols. If any of these measures differs significantly between sample collection sets, comparability may be compromised and data may not be able to be combined for analysis. In this case, separate analysis will be made or the data will be removed from the data set. To increase comparability of data sets, reference methods and SOPs will be followed~~, and~~. ~~c~~Consistency of laboratory methods will be maintained throughout the project.
The comparability goal is achieved through the use of reference methods and SOPs to collect and analyze representative samples, and reporting of analytical results in appropriate and consistent units and reporting limits. This goal is also achieved by maintaining consistency in sampling conditions, selection of sampling procedures, sample preservation methods, and analytical methods.

7.2.6. Completeness

Completeness is a measure of the amount of valid (comparable) data needed to be obtained to satisfy the objectives of the study. Completeness is assessed by comparing the number of valid measurements collected with the criteria laid forth in the DQO. Following statistical procedures used to determine the number of measurements needed, will aid in increasing completeness of the data set. At least 80% of the data collected must meet the performance criteria outlined above for the data set to be considered complete. If criteria are not met, additional sampling rounds will need to be considered to satisfy the DQO.

7.2.7. Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses. In most cases, the sensitivity is the minimum concentration that can be measured by a method, instrument, or laboratory. Individual sensitivities are outlined

Table 7.1. Measurement performance criteria

Analysis	Analytical Method[1]	Data Quality Indicators (DQIs)[2]	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance
Surface & Ground/Soil Water				
Fecal Coliforms (MTF)	SM 9221 B&E	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits

Commented [j22]: I think you can remove this table, the information can better served in other tables. For sensitivity, you should instead have a table that lists lab reporting limits here next to the sensitivity requirements of the project to meet DQOs. (Similar to what you have for field measurements.) Overall – can the instrument provide data that will allow you to make decisions for the project?

Total Nitrogen	SM 4500-A	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Nitrate	SM 4500-NO3 D	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Ammonia N	SM 45002-NH3 D	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Total Phosphorus	SM 4500-P C	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Dissolved oxygen, pH, temperature, nitrate, ammonium, conductivity	In situ, YSI Field Probe	Accuracy, sensitivity	Percent differences, comparison to known value	Field replicates, split samples, field comparison to a known value, calibration of equipment
Ground/Soil Water (only)				
Soil moisture	Gypsum block	Accuracy, sensitivity	Percent differences	Comparison to other validated methods
Air				
Ammonia	In-Situ, Ammonia Analyzer	Accuracy, sensitivity	Percent differences	Replicates, comparison to a known value, calibration of equipment
Nitrous oxide, methane, carbon dioxide	GC-MS	Accuracy, Precision, Bias	Percent differences, no false positives	Blind duplicates, field blanks
Soil				
El. Conductivity	WCC S – 2.30	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Organic Matter	WCC S – 9.20	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Total Nitrogen	SM 4500 - A	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Nitrate	WCC S – 3.19	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Nitrite	SM 4500-NO2 B	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Ammonia N	WCC S – 3.50	Accuracy, Precision, Bias	Percent differences, no false positives,	Method blanks, QC check, matrix spikes,

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			within quantitative limits	duplicates, splits
Total Phosphorus (Brey)	WCC S – 4.20	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
pH	WCC S – 2.10	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
C:N	Calculation	Accuracy	Percent differences	NA
Manure				
Moisture (DM)	TMECC 03.09	Accuracy (precision & bias)	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Nitrate	TMECC 04.02	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Total Nitrogen	TMECC 04.02	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Ammonia N	SM 4500-NH3 D	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Total Phosphorus (Brey)	TMECC 04.03	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
pH	TMECC 04.11	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Total Carbon	TMECC 04.01	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Forage/Crop				
Moisture (DM)	AOAC 934.01	Accuracy (precision & bias)	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Nitrate	AOAC 968.07	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Crude Protein (N)	AOAC 2001.11	Accuracy, Precision, Bias	Percent differences, no false positives, within quantitative limits	Method blanks, QC check, matrix spikes, duplicates, splits
Total Phosphorus	AOAC	Accuracy,	Percent differences,	Method blanks, QC

Commented [j23]: Is this the SOP number, or an analytical method? I am not familiar with it…
Please include a key or reference the full citation.

Commented [j24]: Is this the SOP number, or an analytical method? I am not familiar with it…
Please include a key or reference the full citation.

	958.01	Precision, Bias	no false positives, within quantitative limits	check, matrix spikes, duplicates, splits

[1]*Analytical Method is the method used by Exact Scientific Services laboratory. These methods equate to specific and standard EPA methods (information available upon request).*
[2]*Data Quality Indicators (precision, accuracy/bias, sensitivity, data completeness, comparability, and representativeness).*

Table 7.2. Field instrument performance capabilities

Instrument/Equipment	Parameter	Range	Accuracy	Resolution	Units
YSI Professional Plus Multi-parameter Meter	Dissolved Oxygen (DO)	0 to 50	0.2 (±2%)	0.01	mg/L, ppm
	Temperature	-5 to 70	0.2 (±3%)	0.1	°C, °F, K
	Conductivity	0 to 200	0.001 (±0.5%)	0.001 to 0.1	µS, mS
	Ammonium	0 to 200	2 mg (±10%)	0.01	mg/L-N, mV
	Nitrate	0 to 200	2 mg (±10%)	0.01	mg/L-N, mV
YSI pH10 Meter	pH	1 to 14	±0.1	0.01	units
Kestrel 4000 Weather Meter	Temperature	-45 to 125	1	0.1	°C, (°F)
	Relative Humidity	0 to 100	3	0.1	%
	Barometric Pressure	8.86 to 32.48	0.01	0.05	in Hg, (PSI, mb)
	Wind Speed	0.4 to 60	±3%	0.1	m/s, (mph, km/hr)
	Dewpoint (calc)	-45.0 to 125.0	2	0.1	°C, (°F, %RH)
	Altitude	-2000 to 9000	15	1	m, (ft)
	Heat Index	-45.0 to 125.0	2	0.1	°C, (°F, %RH, inHg)
	Wet Bulb Temp	-45.0 to 125.0	2	0.1	°C, (°F, %RH)
	Wind Chill	0.04 to 60 m/s, -45 to 125	1	0.1	m/s/°C (mph/°F)
Watermark, Soil Moisture Meter	Soil Moisture	0 to 200	±5%	0.1	Centibars/kPa
Stratus Rain Gauge	Rainfall (total)	0 to 11	0.01	0.01	inches
General Tools T300-36 Soil Thermometer (36")	Temperature	0 to 105	1	1	°C, (°F)
Pranalytica Ammonia Analyzer	Ammonia	40 ppb - 100 ppm	40 ppb (10%)	0.01	ppm

Laboratory analysis sensitivity requirements

Analyte	Method	Project Required Reporting Limits, Soil	Project Required Reporting Limits, water	Etc (other applicable matrices)
Total Kjeldahl Nitrogen (TKN)	EPA 351.2	5 mg/kg	0.5 mg/L	

Commented [j25]: Great. Need something similar for lab analyses. (i.e. required reporting limits for each method/anlaysis to meet DQOs.) The labs performing work must be able to meet the MRLs stated (unless there are matrix issues, etc).

Commented [j26]: IS this the instrument sensitivity listed? I.e. the lowest value it can 'see'

Commented [j27]: Example of a sensitivity table for lab analysis.

Commented [j28]: What will you require of the lab? Repoting limits or detection limits? Will they report down to the MDL or just to the checked level of a MRL?

8. SPECIAL TRAINING/CERTIFICATION

No special/non-routine training or certification is necessary for project personnel to obtain field data. The laboratory utilized for this project is a DOE accredited lab and/or has all necessary certification to run required analyses.

The EPA requires that project personnel that will be using STORET attend a training workshop. All personnel responsible for data handling and storage will attend the STORET training as soon as it is available through EPA.

Commented [j29]: What's the routine training policy for sampling? How will you train non-WCD samplers (WWU etc)? Cite the appropriate training or SOP with details.

Commented [j30]: What other accreditations are used? DOE does not provide accreditation for the ag methods that I know of.

9. DOCUMENTATION AND RECORDS

Documents and records will be kept in accordance with EPA standards for the duration of the project as a means of establishing consistency and documentation of project tasks and activities. Records will be kept in both hardcopy and electronic form. Coordination of all recordkeeping will be the responsibility of the Project Manager. Individual documents and information coordinators are outlined in Table 9.1.

Commented [j31]: How will you store the confidential data?

9.1. Project Documents and Procedures

Hardcopies of all up to date QAPP, SOP, and other pertinent documents necessary to successfully carryout the project tasks, will be readily available to all project staff at both the WCD office and in the field operation material bins for the life of the project. Additionally, electronic copies of revised documents will be sent out electronically to all project personnel listed in the section *3 Distribution List* as well as field personnel as necessary.

9.2. Data Collection and Handling Records

All records associated with data collection, handling, and analysis will be kept by the Project Manager. These records include field logbooks documenting sample collection and handling, field notes, meteorological parameters, GPS data, chain-of-custody forms sent with field samples, QC sample records, and equipment calibration information. Data stored in both the WCD and STORNET databases will be maintained by the project Data Manager.

9.3. Other Project Records

Other records maintained include project reports (bi-annual and final), billing and audit reports, project group minutes and rosters, and data summary reports. The following table outlines all documents to be produced and their retention time. In many cases a retention time of 4 years has been listed, as that is the lifespan of the project. If the project extends beyond 4 years, the record retention time will also extend to the new final project date.

Table 9.1. Records and documentation summary

Document/Record Type	Retention Time (yr)	Format (H, E)*	Location
Project Documentation			
QA Project Plan	4	H, E	Director, Project Manager, Project QA Officer

Standard operating procedures (SOPs)	4	H, E	Project Manager
Field Records			
Field and laboratory notebooks	6	H	Field Technicians, Project Manager
GPS data	6	H, E	Project Manager
Sample handling/labeling/custody records	6	H	Project Manager
Site information, maps, and photos	6	H, E	Project Manager
Analytical Records			
Inspection/Maintenance/Calibration records	4	H, E	Project Manager
Data Records			
STORET Database	4	E	Data Manager
Excel spreadsheets	6	E	Data Manager
Original field data sheets	6	H	Project Manager
Assessment Records & Reports			
Meeting and presentation logs	4	H	Project Manager
Data summary reports	4	H, E	Project Manager
Quarterly and final reports	4	H, E	Administrator, Project Manager
Billing and audit reports	4	H, E	Administrator
**H = Hardcopy, E = Electronic*			

10. SAMPLING PROCESS DESIGN

The follow section describes the projects research experimental design for data collection. The selected probability-based experimental design should give a representative view of the target population using a smaller subset of that population. In general, the goal of the sampling program outlined in this document is to monitor trends in environmental conditions based on current and modified practices. More specifically, the aim of the project is to assess the affect of different manure application schedules and guidelines on the partitioning and cycling of nitrogen using a systems approach by concurrently measuring concentrations in ground/soil water, surface water, air, and soil. In addition to nitrogen, the affect of a new application system will be assed for fecal coliform and phosphorous in soil and surface water. Trends, correlations, effects, and relationships will be assessed for all constituents outlined in this sampling program.

Commented [j32]: How?

The project runs from July 1, 2010 to June 30, 2014. During that time period we expect four monitoring years, with four seasons per year. The number of farms, fields, and samples taken is outlined below.

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10.1. Sampling Design Rational

The sampling design for this project is broken down into various parts. First, test farms within the area of study (the watershed) are selected. Test farms are selected on either 1) a random basis where they come to WCD as plan updates are necessary and agree to participation in the study, or 2) they are selected from an area of interest within the watershed (systematic selection). Second, test fields are chosen from all fields available at a test farm. Since all fields can not be sampled, one or more fields are selected that are representative of the area (systematic selection).

In the case of paired sampling efforts, two fields with the same characteristics will be chosen for accurate comparison. Third, test locations within the field are selected. Many fields have more than one soil type, so an area that represents the primary (>50%) soil type will be chosen when this is the case (stratified random selection). The location of the co-locate sample site within the field area will be randomly selected from a field grid. Areas that are not representative of overall field conditions or contain geological or wetland areas will be blocked off of the grid. The individual sample design and protocol of each parameter measured is outlined below. Parameters to be measured include: surface water, ground and soil water, soil moisture, air, soil, manure, forage, and meteorological conditions.

10.2. Sample Strategy and Numbers

10.2.1. Test Site Number

Sample numbers are dependent on the parameter measured and the confidence level desired. We have chosen to sample multiple fields at 10 farms per year to account for variability in soil type, weather patterns, management, technologies, etc. throughout the watershed. Since there are no prior data to determine population variance or the CV for fields conditions within the watershed, an exact sample size to meet pre-specified conditions is not available ($n = t^2CV^2/E^2$, where n = sample size, t = Student's t statistic for CV, CV = coefficient of variation, and E = acceptable error as a proportion of the mean). However, by using an iterative confidence interval approach to estimating sample size, we have determined that 10 sample farms is sufficient to minimize variability between farms at a 95% margin of error. The first year of the project, we will have five test fields/farms to assess sampling methods and strategies. Starting in year two, the project will add 10 additional farms per year for a total of 35 farms, which should be more than sufficient to reduce variability and allow a projection of results over the watershed area, rather than be limited to the sample site. However, comprehensive sampling of all mediums (surface water, groundwater, soil, air, manure, and forage) and all analytes will only be conducted over the entire project period on test farms enrolled in years one, two, and three. This is because, while one year is sufficient to show a trend in variability between seasons, one year of data are not sufficient enough to account for variability in nutrient cycling within seasons. Farms enrolled in year four of the study will primarily be utilized for testing of ARM system tools and components and will have limited and targeted testing done based on previous study results as to which measures are most important for entry into the ARM worksheet (i.e., nitrogen in soil, soil moisture, and soil temperature).

10.2.2. Field Numbers

In order to decrease variability within test farm sites, multiple fields per farm (1 to 3+) will be measured. A test field will be defined as an area of only one soil type. Based on that definition, one farm field can have multiple soil types and field test units. The number of test fields selected will depend on ARM risk rating characteristics, the variability between fields on the farm, and the crops grown. Variability is expected, but should be within the selected margin of acceptable error (10% CV). The selection process for test fields will be consistent for all test farms. When applicable, paired test and control fields will be used to measure the difference between application strategies and practices. Paired fields will need to be adjacent to each other to ensure they have the same soil type, weather influences, groundwater depth fluctuations, crop, and management. Pair fields will be selected based on availability.

10.2.3. Medium Numbers

The number of samples taken at each site throughout the year will vary depending on the medium. Current sampling protocols are designed to have the least amount of variability and still stay within sampling budget. The total number of samples (n) to be taken per medium, over the entire project lifetime (4 years) is shown in Table 10.1 (numbers subject to change). More specific frequencies of sampling are outlined in section 10.3. While it is not anticipated, if the CV is outside of acceptable limits, sampling protocols will be revised to include more sampling events to achieve the level of error specified in this plan.

Note: Sample number may change (no significant decrease expected) depending on additional outside funding, price adjustments, and project assessment. Any increase in sample number will benefit the project objectives.

Table 10.1. Estimated sample numbers over the project lifetime for each medium and analyte (number subject to change (+/-) with budget, sample protocol revision, and equipment)

Sample Medium	Analyte(s)	Estimated Number (n)
Water (Surface)	FC	1,935
	Total N	1,935
	Nitrate, Cl^-	96
	Total P	1,735
	DO, pH, temp, conductivity, nitrate, NH4	6,450
Water (Soil/Ground)	FC	20
	Total N	600
	Nitrate, Cl^-	25
	Total P	300
	DO, pH, temp, conductivity, nitrate, NH4	1,170
	Soil moisture	16,000
Soil	EC, OM, TKN, NO3, P, pH, NH3-N	1,095
	Mineral profile, cation exchange	100
	TKN, NO3, NH4, total P, C:N	360
Manure	Moisture, TKN, NH4-N, total P, K	1,100
	Nitrate	10
Air	GHG (CO_2, CH_4, N_2O)	1,095
	Ammonia	1,095
Forage	DM, CP (N), P, nitrate, TDN	180

Commented [j33]: Chloride?

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Commented [j34]: Most analytical methods are NH4+NH3, reported NH3 as N

Commented [j35]: Verify exactly which forms of ammonia or ammonium (or both) are reported by the methodology used.

Commented [j36]: Include key for analytical acronyms.

10.3. Sample Types, Locations, and Frequencies

Each of the environmental parameters measured is outlined below along with sample locations and frequency of sampling. Actual analytes measured for each parameter are listed in Table 10.1.

10.3.1. Surface Water

Commented [j37]: Cite SOP for collection.

In-stream. Surface water will be collected from test fields that have adjacent waterways (i.e., field ditches, streams, creeks, rivers, wetlands, etc.). Surface water samples will not be taken from fields that do not have adjacent waterways. Prior to each measurement, the sample location will be noted with GPS coordinates, and field and weather conditions recorded. Then, a sample from each waterway located adjacent to the test field will be collected upstream (sampling

location background), and downstream (source pollution) of the field and assessed using a paired model. The difference of the two measures is the pollution contributed by processes within that field. In order to make sure the same water "particle" is being sampled, the water flow velocity will be determined prior to sampling ($Q = d/t$, where Q = flow rate (ft/s), d = distance between point A and B (ft), and t = time from point A to B (s)). The flow rate will help determine the time necessary to wait between taking upstream and downstream water samples. A water quality sample will be taken 24 hours before and 24 hours after every field application (approximately 1-6 per year depending on crop). Additional samples will be taken during storm events when runoff events are possible (approximately four per year). Visual appraisal of field conditions and runoff events will also be conducted and recorded during storm events. If a waterway is dry or very low (<10% of normal flow), no samples will be taken. Samples will be taken at the same location for each measurement cycle to reduce variability.

Overland. Secondary runoff measures will be taken within buffer areas (0-100 ft) to determine the effectiveness of buffers and manure setbacks at limiting nutrient and pathogen runoff. Measurement devises (5 gal pan lysimeters) will be installed at a subsurface (1 inch) level to determine overland flow and concentration. The flow collectors will consist of a 5 gal bucket buried to 1 inch below the soil surface with a permeable lid topped with inert sand substrate (will be tested) to allow overland flow to flow into the collection container. Flow collectors will be permanent installations over the project lifetime. Samples of pan contents will be taken after significant rain events in conjunction with stream measurements and all the same analyses will be conducted.

Commented [j38]: Curt Black is going to comment on the lysimeters and overland/ soil water/GW collection sampling technique and plan.

10.3.2. Ground and Soil Water

Commented [j39]: Site SOP for collection.

Soil Water. Soil water samples will be taken at one area location in each test field using a variable tube technique (lysimeter). The sample area chosen will be representative of the majority (>50%) of the field. Both suction and pan lysimeters will be installed in test fields at 3 to 5 foot spacing so that sample areas do not overlap, and at depths of 6, 12, and 24 inches. While the pan lysimeter will be the primary method utilized for measurement of soil water, some suction lysimeters will be installed as a validation and secondary measurement. Suction lysimeters work by creating a vacuum inside the sampler that is greater than the soil water tension, thus allowing the soil water to flow from the soil pores into the ceramic cup sampler to be collected and tested. This is an effective way to measure soil water at specific soil horizons in saturated, wet, or heavy textured soils, but can overestimate soil concentration due to the accelerated wicking action. Pan lysimeters are passive samplers that collect soil water that has gravitationally percolated through the soil profile and into a filtered collection bucket. The cumulative liquid collected is pumped out of the bucket and sampled. Pan lysimeters are an effective way of characterizing the nutrient and pathogen composition of soil water from precipitation that has naturally flowed through the soil profile to a specific depth, but are only effective with precipitation. Both methods are being used in order to get an accurate picture of the various soil water processes and transport occurring throughout the year under precipitation (pan), groundwater flux (suction), and natural soil moisture (suction) conditions. In both cases, the permanent lysimeter samplers need to be installed carefully under the soil surface at the specified depths without causing a significant change to the surface above it. This will be done by excavating a pit and installing the samplers into the exposed area, rather than digging a hole and burying them. Since soil water samples can only be taken when there is soil water present, sampling will not be conducted when the soil is dry (co-located soil moisture probes will help

determine moisture content), or there has been no significant precipitation. When conditions are favorable, soil water samples will be taken 24 hours before every manure application event, and 48 hours after. Soil water will also be sampled once every two weeks from September through February to characterize soil water at various depths over time.

Groundwater. Groundwater samples will be taken at those field locations that already have monitoring wells installed. When wells are present, soil water samplers will be co-located with the monitoring wells to give comparable measures. Groundwater depth will be determined first by using a measuring stick, and then a sample of the groundwater will be taken by inserting a sterile Tygon tube into the well and pumping a sample into a sterile sample container. Groundwater samples will be taken at the same frequency and time as soil water samples for comparison and added data.

Groundwater Depth. For those fields without monitoring wells installed, a groundwater depth monitoring tube will be installed down to 6 feet below the soil surface following DOE Standards for Construction and Maintenance of Wells and USACOE guidelines. The tube will be a 6 foot, 2 inch diameter PVC pipe with a float, installed with a boring probe. When not in use, the tube will be tightly capped. The tube will help determine the groundwater depth to surface level (0-6 feet) at all times of the year to see its effect on transport and dilution of nutrients in the soil profile. In areas where installation of a monitoring tube is not practical or allowed, a hole, no deeper than 4 feet will be dug, or secondary factors (i.e., ditch levels, creek levels) will be utilized for determining groundwater depth to surface.

Soil Moisture. Soil moisture will be determined using a resistance (gypsum) block. To monitor soil moisture across the field, two gypsum blocks will be buried 12 inches deep at representative locations in each field, and an additional three blocks will be co-located with pan lysimeter locations at 6, 12, and 24 inches deep (only 12 and 24 in corn fields due to tillage practices). Each block will be installed with a 1.5 inch diameter auger and soil will be packed back after installation. The location of each block will be marked with GPS coordinates. Measurements will be taken each time any other constituent is measured, including before and after manure application, during big storm events, randomly throughout the year at the same times as soil, surface water, and groundwater samples, and at any other time of interest. When gypsum blocks are being installed, a characterization of the soil profile (soil core) above the block will be recorded.

10.3.3. Air

Commented [j40]: Cite SOP for collection

Ammonia and greenhouse gas (nitrous oxide, methane, carbon dioxide) measurements will be taken one day before and at 1, 2, and 7 days after each manure application event. Ammonia and greenhouses gases will be also sampled randomly once monthly throughout the year, not to coincide with manure application events. All sample locations will be recorded with GPS so that subsequent samples may be taken in the same area.

Ammonia. Ammonia will be measured using an EPA approved photoacoustic real-time analyzer (Nitrolux-S, Pranalytica, CA) along with a surface collection system. Two types of surface collection systems will be utilized: point and composite. The point system consists of one HDPE sampling line, which is staked 4 inches above the ground surface, connected directly to the ammonia analyzer, and sampled at a rate of 1 lpm. This set-up is used when a single and defined point is desired to be measured. The composite surface collection system consists of 6 HDPE sampling lines protected by a 6 inch diameter PVC cap staked 4 inches above the ground surface.

Commented [j41]: Method?

The cap is used to prevent moisture, dust, and dry deposition of gas from entering the sampling lines. The sampling lines, staked randomly in a set area, collect ambient air under vacuum into a composite sampling device. The PVC sampling device pulls air from the sampling lines at equal rates and mixes it in a closed, circulated container. From this mixed sample, the real-time ammonia analyzer actively collects a sample of air at a fixed rate of 100 cc/min. Samples are logged every 120 seconds for accurate analysis of surface ammonia concentration trends and variations over time. The system is unique because it does not disturb the normal surface flux behavior, and thus does not alter the rate and concentration of surface emissions like other measurement devices can (i.e. flux chambers, wind tunnels, etc.).

GHG. Greenhouse gases will be measured on-farm using the accredited syringe technique method. Both ambient and plot samples, which will be co-located with the soil water sampling locations, will be taken. These measurements, conducted in partnership, will be sent to Agriculture and Agri-Food Canada for analysis.

Commented [j42]: Method/source of accreditation

10.3.4. Soil

Commented [j43]: Cite SOP for collection.

Soil Sample. Soil samples will be taken using a simple randomized design with composite analysis. Every test field will be sampled at one (0-12 inches) to three depths (0-6, 6-12, and 12-24 inch). Depths were chosen because they are at plow depth, root zone depth, and below root zone depth, respectively. Samples will be collected before each manure application to evaluate agronomic application rates. Samples, co-located with ground/soil water equipment, will also be taken once monthly from September to February at 6, 12, and 24 inches at the same time as soil water samples and tested for nitrate. All sample locations will be recorded with GPS so that subsequent samples may be taken in the same area. An appropriate number of samples will be taken for each depth on each test field according to field size, procedures for EPA randomized grid designs, mixed as a composite sample, and sub-sampled. At minimum, the number of sample cores that will make up a composite sample will be 10 samples for each of the various sample depths. One sample per field, per depth, plus any QA duplicates, will be sent for analysis.

Commented [j44]: 30 is usually the optimum number of cores for a representative MIS / composite sample from a statistical perspective. (Depends on uniformity and size of decision unit though.) 10 would be the absolute minimum. However, I realize that would take a long time for each of the3 different depths.

Soil Temperature. Soil temperature at surface (0), 6, 12, and 24 inches will be determined with a hand held probe thermometer (36 inch) at all soil-water, air, and soil sample locations at each sampling. Measurement locations will be marked with GPS and results recorded in a field logbook.

10.3.5. Manure

Commented [j45]: Cite SOP for collection procedures.

Manure samples will be taken at each manure application event. Two types of samples will be taken, one that is representative of the entire field (composite), and one that is specific to the location of the soil water samples. This will help us understand the specific contribution to the nutrient profile in the area over the samplers, as well as the profile for the entire field for broader conclusions. Depending on lagoon management and application technology, manure applied to farm fields can vary in concentration throughout the application time period. Therefore, a composite sample will be obtained by taking a sample from the manure applicator approximately every 10,000 gal applied, or over the soil water samplers for the specific location case. If tests show consistency between the samples (<10% variation), then only one sample needs to be taken at each application event (specific).

Commented [j46]: What does this mean exactly?

10.3.6. Crop/Forage

Commented [j47]: Cite SOP for collection procedure

Both composition and crop yield data (lbs/acre) will be obtained at each harvest/cutting for each test field. This is approximately four-six samples for grass and one for corn per year. Yield will be measured immediately prior to harvest by using a box and cut method where a known area is hoped off (3 ft diameter) and cut by hand at approximately the same height as the harvesting equipment. The total yield (*Y*) in lbs/acre is measured by $Y = (Y_{wet} \times DM)/Area$, where Y_{wet} is the wet weight of the forage harvested in the field (lb), *DM* is the dry matter determination by the lab (%), and *Area* is the total area of the sample hoop (acre). A yield estimate from the producer will also be obtained and recorded for comparison. After the field is cut by the producer, a composite grab sample that is representative of the entire field will be taken and sent in for total analysis.

10.3.7. Meteorological

Commented [j48]: Cite SOP

Meteorological data including ambient temperature, relative humidity, wind speed, wind direction, pressure, altitude, dewpoint, and wet bulb temp will be recorded in the field using a portable handheld weather monitor (Kestrel 4000). The weather monitor will be set up in the field during sampling campaigns at the same location as soil moisture equipment. Data will be recorded at various heights (i.e., ground level, 6 feet) depending on the parameter being measured (e.g., air quality, surface runoff, etc). See Table 7.2 for instrument details.

Precipitation will be measured at each test site with a rain gauge. The rain gauges will be installed permanently on-site according to proper installation procedures outlined by the manufacturer. Observations will be made on a daily basis by the farm operator and recorded in a log book.

Meteorological data will also be recorded from permanent sites located throughout the county (see Table 10.2). Field data will be compared to these sites for correlation and validation purposes. Forecast data will also be obtained and recorded from external sites. Table 10.2 shows various meteorological sites and their measures to be consulted during the project.

Table 10.2. Meteorological sites consulted and measures recorded as part of the project data

Site	Address	Measures Recorded	Days Forecasted Out
NOAA	www.wrh.noaa.gov	Temp, precip (predicted, 6hr), RH, wind speed, wind dir	4
NOAA - Quick Forecast	forecast.weather.gov	Temp, precip (predicted, 12 hr)	3
University of Washington - Probcast	www.probcast.com	Temp, precip (predicted, 12 hr)	2.5
Farmers Forecast	www.weather.com	Temp, precip (predicted, 12 hr), wind speed, wind dir, GDD*	1.5
Washington State University - AgWeatherNet	weather.wsu.edu	Temp, precip (current), soil moisture, soil temp, wind speed, solar radiation, leaf wetness	Current, Historical
Farm West	www.farmwest.com	Temp	5
Weather Underground	www.wunderground.com	Temp, precip (historical), RH, wind speed, wind direction	2, Historical

**GDD = Growing Degree Days*

11. SAMPLING METHODS

The procedures for sample collection including methods, equipment, collection materials, preservation techniques, and decontamination procedures are listed below as well as in Table 11.1. All sample container types, and volumes are specified by the laboratory. All holding times and storage conditions are specified by the laboratory following EPA required procedures outlined in 40 CFR Part 136. Individual SOPs for each medium measured will be available to project personnel to ensure consistent sampling procedures throughout the project.

11.1. Sample Collection, Preparation, and Decontamination Procedures

Commented [j49]: Cite applicable SOPs and or Methods.

11.2.1. Surface Water

In-stream. Three samples will be taken for water quality samples, one for fecal coliform analysis (FC), one for lab analysis (i.e., total-N, nitrate, Total-P, etc) (lab), and one for field analysis (field). Surface water will be collected into 120 ml (FC), 250 ml (lab), or 500 ml (field) sterile environmental testing bottles provided by the state-certified testing laboratory. Each labeled bottle will be uncapped and inserted into the center of the stream flow or out 5 feet from the stream bank (whichever is most appropriate for the waterbody size), and a sample will be collected into the bottle. The FC sample will be collected first, and then the two 250 and 500 ml bottles will be collected in unison. The 120 ml and 250 ml sample containers will be capped immediately, taking care not to touch the lip of the bottle or inside of the cap, and placed in a chilled (≤6 °C), UV protected cooler. The clean field analysis probe will be inserted into the 500 ml container for real time analysis of measures listed in Table 11.1. All results will be logged into the meter as well as recorded into a field notebook. After the analysis is complete, the uncontaminated sample will be returned to the waterway from which it came and the analysis container and sample probe will be rinsed thoroughly with DI water. FC and lab samples will be stored in the chilled cooler and taken to the laboratory for analysis the same day. If same day drop off is not possible, samples will be stored in a refrigerator overnight and taken to the laboratory within 24 hours of attainment. A field replicate, treated in the exact same way, will be taken every twentieth sample for FC and lab samples and sent for analysis. Field samples will be split every twentieth sample and analyzed for variability.

Commented [j50]: Lab analyses with acid preservation require addition at the time of collection.

Commented [j51]: Is extra sample volume needed by the lab for QC? (i.e. lab dup/MS/MSD?)

Overland. Any overland flow collected by the bucket sampler will be pumped through Tygon tubing with a hand pump from the bucket into a sterile 120 ml (lab) and 250 ml (field) container. If there is excess liquid in the bucket, it will all be pumped from the container down-gradient into the field so that the preceding sample period is distinguished from the last. The 120 ml container will be handled in the same manner as describe above for lab samples and the 250 ml container will be handled as a field sample. All analysis will be the same as for in-stream samples.

Commented [j52]: Acid preservation

11.2.2. Ground and Soil Water

Soil Water. Soil water will be collected as described in section 10.3.2. using both a pan and suction lysimeter. For the pan lysimeter, soil water collected in the pan will be pumped through Tygon tubing using a hand pump and into a sterile collection vessel. The sample will be transferred from the collection vessel into 120 ml (FC, lab) and 250 ml (lab and field) sterile environmental testing bottles provided by the state-certified testing laboratory. The lab sample will be capped immediately, taking care not to touch the lip of the bottle or inside of the cap, and placed in a chilled (≤6 °C), UV protected cooler. The clean field analysis probe will be inserted

Commented [j53]: Acid preservation

into the filed 250 ml container for real time analysis. All results will be recorded by the meter as well as entered into a field notebook. In the case of low collection volumes (<100 ml), fill preference will be given to the laboratory sample. If a field sample is not able to be obtained, field measures (i.e., nitrate, ammonium, EC, DO) will be conducted by the laboratory instead. After the analysis is complete, the uncontaminated sample will be returned to the field from which it came and the collection vessel and sample probe will be rinsed thoroughly with DI water. Lab samples will be stored in a chilled (≤6 °C) cooler and taken to the laboratory for analysis the same day. If same day drop off is not possible, samples will be stored in a refrigerator overnight and taken to the laboratory within 24 hours of attainment. A field replicate, treated in the exact same way, will be taken every twentieth sample for lab samples and sent for analysis. Field samples will be split every twentieth sample and analyzed for variability.

Groundwater. When available, groundwater samples will be obtained from monitoring wells by inserting a sampling tube into the well and pumping the liquid from a specified depth into a collection vessel. The sample will then be split into two 100 ml (FC, lab) and 250 ml (field) sterile environmental testing bottles provided by the state-certified testing laboratory. The lab sample will be capped immediately, taking care not to touch the lip of the bottle or inside of the cap, and placed in a chilled, UV protected cooler. The clean field analysis probe will be inserted into the 250 ml container for real time analysis. All results will be recorded into a field notebook. After the analysis is complete, the uncontaminated sample will be returned to the field from which it came and the collection vessel and sample probe will be rinsed thoroughly with DI water. Lab samples will be stored in a chilled (≤6 °C) cooler and taken to the laboratory for analysis the same day. If same day drop off is not possible, samples will be stored in a refrigerator overnight and taken to the laboratory within 24 hours of attainment. A field replicate, treated in the exact same way, will be taken every twentieth sample for lab samples and sent for analysis. Field samples will be split every twentieth sample and analyzed for variability.

Commented [j54]: Acid preservation.

Soil Moisture. Soil moisture will be determined using resistance (gypsum) blocks buried in each test field and marked using GPS. Resistance blocks work by absorbing water into the gypsum, which is cast around two electrodes, dissolving some of the gypsum and effectively lowering the resistance for an electrical current to be passed between the two electrodes. The more water that enters the gypsum block, the lower the resistance. To ensure proper functioning, the block will be installed at the proper depth using an auger no wider than the probe diameter. After it is inserted into the soil profile, the block will be covered and the soil temped firmly to remove any possible air pockets in the soil which can skew readings. To measure the soil moisture level, the block electrodes will be connected to a handheld monitor and the reading recorded in a field log book. Gypsum blocks will be left in the soil for the entire sampling period. If one is lost due to plowing activities, etc., it will be replaced in the same area.

11.2.3. Air

Ammonia. Ammonia will be measured using a photoacoustic real-time analyzer (Nitrolux-S, Pranalytica, CA) and surface collection system as described in section 10.3.3. Sample locations will be co-located with soil water samplers, as well as randomly throughout the field. Samples are logged every 120 seconds. After a one to two cycle adaptation period, sample areas will be measured for approximately 10 minutes prior to moving to the next sample location. A background (ambient) sample will be taken for a minimum of 10 minutes prior to sampling for validation/quality control. All ammonia data is logged into the analyzer, downloaded onto a USB, and analyzed with Excel.

GHG. Greenhouse gas samples will be taken using a syringe technique. Ambient samples will be taken by slowly pulling air into a 60ml syringe at a rate of 1 ml/sec and injecting the air into a labeled vacutainer. Plot samples will be taken by pulling an air sample from the composite sampler outlined above at the same time as ammonia measurements are made. Samples will be injected into vacutainers, stored in a UV protected container (temperature not an issue), and sent to Agriculture and Agri Food Canada for GC analysis within seven days of each sampling event. For quality control, a split field replicate, will be taken every twentieth sample and sent in for analysis.

Commented [j55]: What about other field QC? Field dups (same lab), Blanks/rinsates, QC lab volume and frequencies? Applies to all matrices. You discuss this below, but may want to cite here as well.

11.2.4. Soil

Soil samples will be taken at one (0-12 inches) to three (0-6, 6-12, and 12-24 inches) depth segments using a clean and dry handheld soil probe. If a foot driven soil probe is impractical due to soil type (dry, rocky, etc.), a hand held auger will be used to extract the sample. To obtain the segments with the probe, a 24 inch soil probe will be inserted into the soil and the core extracted. The core will then be divided into the three segments using a ruler. Each sample for each depth will be transferred into a separate, clean plastic bucket and mixed thoroughly using a gloved hand. A 500 ml homogeneous sub-sample of each composite sample will be taken and transferred into two 1 liter, labeled, sterile plastic bags. Samples will be stored and transported in a chilled (<10 °C), closed container. The container will be maintained under dry conditions using frozen gel packs. One sample will be stored for reference at -20°C and the other will be taken to the laboratory on the day of sampling. If same day drop off is not possible, samples will be stored in a refrigerator for no more than 48 hours prior to transport to the laboratory. A field replicate, treated in the exact same way, will be taken every twentieth sample and sent in for analysis.

11.2.5. Manure

Manure samples will be taken at each manure application event using the catch method (for aerator, splash plate, or big gun methods). A composite sample of manure will be collected into a bucket, thoroughly mixed, and two homogeneous 1000 ml sub-samples will be transferred into sterile plastic sample containers. Samples will be stored and transported in a chilled (≤6 °C) container. One sample will be stored for reference at -20°C and the other will be taken to the laboratory on the day of sampling. If same day drop off is not possible, samples will be stored in a refrigerator for no more than 48 hours prior to transport to the laboratory. A field replicate, treated in the exact same way, will be taken every twentieth sample and sent in for analysis.

11.2.6. Crop/Forage

Crop yield data (lbs/acre) will be obtained at each harvest/cutting as described in section 10.3.6. For forage/crop composition, a composite sample from each harvest will be obtained by grab method, thoroughly mixed in a clean bucket, sub-sampled, and placed in a clean one liter plastic bag. Samples will be stored dry in and transported in a chilled (≤10 °C), closed container. One sample will be stored for reference at ≤4 °C and the other will be taken to the laboratory on the day of sampling. If same day drop off is not possible, samples will be stored in a refrigerator for no more than 48 hours prior to transport to the laboratory. A field replicate, treated in the exact same way, will be taken every twentieth sample and sent in for analysis.

11.2.7. Meteorological

Meteorological data will be recorded in the field using a portable weather station (Kestrel 4000). The station will be taken to each sample location and parameters will be logged by the station in 2-3 second intervals over the entire sampling period. The current weather parameters will also be recorded in a log book at the start and end of each sampling exercise for all mediums sampled. Precipitation measurement will be recorded and reset at each sampling event. Data will be entered and/or downloaded after each sample day and analyzed and stored accordingly.

Table 11.1. Sample collection and storage requirements for mediums and analytes collected (maximum holding times for water mediums are taken from 40 CFR Part 136)

Sample Medium	Analyte	Analysis Method*	Sample Volume	Container Type	Preservation Technique	Max Holding Time
Surface Water	Fecal Coliform	Laboratory	120 ml	Sterile plastic bottle	Ice bath (field, transport) or refrigerator (office); 0.0008% $Na_2S_2O_3$ if Cl^- present	6 hr at ≤10 °C (EPA); 6-30 hrs at <4 °C (WSDOE)
	Total N, TKN, ammonia, total P, Cl^-	Laboratory	250 ml each (1 L for all samples)	Sterile plastic bottle	Ice bath (field, transport) or refrigerator (office); acidified with H_2SO_4	48 hrs at 4 °C; 28 d at ≤6 °C if acidified with H_2SO_4
	Nitrate	Laboratory	250 ml	Sterile plastic bottle	Ice bath (field, transport) or refrigerator (office)	48 hr at ≤6 °C
	Dissolved oxygen (DO), temperature, conductivity, nitrate, ammonium-N, pH	Field Meter	500 ml	Clean plastic bottle	NA	NA
Ground/ Soil Water	Total N, TKN, ammonia, total P, Cl^-	Laboratory	250 ml each (1 L for all samples)	Sterile plastic bottle	Ice bath (field, transport) or refrigerator (office); acidified with H_2SO_4	48 hrs at 4 °C; 28 d at ≤6 °C if acidified with H_2SO_4
	Nitrate	Laboratory	250 ml	Sterile plastic bottle	Ice bath (field, transport) or refrigerator (office)	48 hr at ≤6 °C
	Fecal Coliform	Laboratory	120 ml	Sterile plastic bottle	Ice bath (field, transport) or refrigerator (office); 0.0008% $Na_2S_2O_3$ if Cl^- present	6 hr at ≤10 °C (EPA); 6-30 hrs at <4 °C (WSDOE)
	Dissolved oxygen (DO), temperature, conductivity, nitrate, ammonium-N, pH	Field Meter	250 ml	Clean plastic bottle	NA	NA
	Soil Moisture	Gypsum block	NA	NA	NA	NA
Air	Ammonia	Field Meter	1 lpm	NA	NA	NA

Commented [j57]: All samples must be preserved in the field at the time of collection according to the EPA approved methods. Therefore, all holding times are 28 days. (Remove 48 hours)

Commented [j56]: I see chloride in the table, but not anywhere else in the document. Is Cl- analysis planned? If so, note that it is NOT preserved.

Commented [j58]: Does the field probe only measure NH4 and not NH3?

Commented [j59]: Same Cl- comment.

	Methane, nitrous oxide, carbon dioxide	Laboratory	10 ml	Vaccutainer	Cool, dry, dark box	6 mo days in a closed, dark container at ≤20 °C
Soil	EC, OM, FC, total N, nitrate, total P, pH, C:N, minerals	Laboratory	1 L~~liters~~ (dry)	Whirl Pak - Sterile plastic bag	Closed container; ice block (field) or refrigerator (office)	48 hr at ≤6 °C (dry); or indefinitely at -20 °C
Manure	EC, OM, C:N, FC, total N, ammonium, nitrate, total P, K	Laboratory	1 L (dry); 1000 ml (liquid)	Whirl Pak (solid); Clean plastic bottle	Closed container; ice bath (field) or refrigerator (office)	48 hr at ≤4 °C; or indefinitely at -20 °C
Forage	DM, CP (N), P, nitrate, TDN	Laboratory	1 liter (dry)	Whirl Pak - Sterile plastic bag	Closed container; ice bath (field) or refrigerator (office)	48 hr at ≤4 °C (dry);

** See Table 7.1 for laboratory analytical method reference for each analyte*

Commented [j60]: Recommend a fully closing bag if that is going to be used to ensure sample integrity– ziplock type instead of whirl pak.

11.2. Plan for Sampling or Measurement Failure

All sampling procedures and protocols assume proper functioning of equipment as well as proper attainment, processing, and delivery of samples. In the event that something does not go as planned during field sampling, back-up protocols will be in place. If the problem is beyond available protocols or a simple fix, the field team may identify and determine an alternative course of action, which must be approved prior to implementation by the WCD Project Manager. The problem and corrective action will be documented in the field log book.

To necessitate quick action, extra sample vials/bags, probes, tubing, etc. will be available in the field. If an unfixable problem occurs with field sampling equipment, it will be replaced as quickly as possible, as back-ups are not usually feasible due to cost. If samples are not properly stored, or lost, a make-up sample day will be scheduled if possible. If this is not possible due to weather conditions, etc., the missing data will be noted and appropriately documented in the data set.

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12. SAMPLE HANDLING AND CUSTODY

Sample processing and handling is a vital part of the organization, integrity, and longevity of the sample protocol. The following explains the storage and transport conditions of the samples, the labeling and tracking system, and the chain of custody.

12.1 Sample Storage and Transport

As outlined in Section 11, all samples will be collected into the proper containers, placed into a chilled temporary storage cooler, and transported to either a secondary holding area (fridge at 3° C or freezer at -20° C) or the laboratory according to maximum holding times listed in Table 11.1.

Commented [j61]: Preserved as required,

12.2. Sample Handling and Tracking System

All samples obtained will be recorded in ink in a bound field log book. Any corrections to information entered into the log book will be lined~~striked~~ out using a single line and signed and dated by the sampler. The information recorded will include:

- date,
- time of each sample collection,
- GPS coordinates of each sample location,
- site number,
- field number,
- sample number (add a "D" for duplicate and "B" for blank),
- sample medium type,
- analysis being performed (lab or field),
- weather parameters and conditions,
- field conditions (crop, cover density, ponding, etc.),
- person performing sampling,
- laboratory sent to,
- and holding time between collection and analysis.

Any other noteworthy items will also be recorded including photos taken to document field conditions and sample procedures. For samples analyzed in the field (dissolved oxygen, pH, temperature, conductivity, nitrate, ammonium-N, soil moisture, ammonia, and meteorological conditions), the same information will be recorded along with analyte results.

All sample containers will be labeled according to a code system which contains information including:

- sample type (i.e., medium, analyte, technology),
- site number,
- field number,
- date,
- and sample number (add a "D" for duplicate and "B" for blank).

When possible, the label code will be written directly onto the sample container in permanent ink, otherwise, the sample identification information will be written on a label, which will be affixed to the sample container.

12.3. Chain of Custody

Samples will be packaged and shipped, or hand delivered to the laboratory as soon as possible (see Table 11.1) by the field technician. A chain-of-custody form supplied by the laboratory will

Commented [j62]: When will the COC be completed? In the field at the time of collection? What are the custody requirements?

be filled out and submitted with samples. Copies of forms will be retained by the Project Manager.

13. ANALYTICAL METHODS

The majority of sample analysis is done by analytical laboratories that have their own methods (SOP), performance standards, and reporting procedures in place according to approved protocols. These documentations will be available by the laboratory upon request. In-situ field sampling will be conducted following procedures outlined by the manufacture or approved in the QAPP.

An example section:

Samples designated for off-site analytical laboratory analyses will be submitted to the labortories specified in table X. Table XX summarizes the laboratory instrumentation and methods to be used for this project

All instruments and equipment used during field and fixed laboratory sample analyses will be operated, calibrated, and maintained according to the manufacturer's guidelines and recommendations, as well as criteria set forth in the applicable analytical methodology references.(see tables and appended SOPs).

In cases where laboratory results exceed QC acceptance criteria, reextraction and/or reanalysis will occur as indicated in the applicable analytical method. The respective laboratory analysts will be responsible for ensuring that appropriate sample analysis procedures are followed and take appropriate actions to ensure deficiency correction.

Commented [j63]: No. The lab must follow an appropriate analytical method (EPA /Ecology approved where available) which is supplemented by their specific lab procedures. The requirements are stated in the Method and the QAPP for QC. Their SOP is will list method deviations and lab specific QC – the project must determine if this meets project DQOs.

13.1. Analytical Methods

All samples will be collected, handled, and processed as described in sections 11 and 12. Standard operating procedures (SOP), methods, and laboratories are outlined for each analyte in Tables 7.1 and 13.1. The laboratories used will follow ~~their own SOP for each analyte analysis~~the analytical methodology specific and their lab SOPs for analysis. It is unexpected, but if any modification of method needs to be done by the lab, ~~a copy of the modified SOP will be obtained~~it will be stated in the laborotory's SOP. All SOPs for in-situ field sampling are available from the project manager.

Commented [j64]: Append to final QAPP or cite SOP by reference / document number.

Table 13.1. Standard operating procedures (SOP) and laboratory used for matrix analysis

Matrix	Analyte	Primary Testing Method	Data Turn Around Time	Primary Laboratory	Secondary Laboratory
Surface Water	Fecal Coliform	Laboratory	48 hours	Exact Scientific Services 3929 Spur Ridge Lane, Suite 1 Bellingham, WA 98226	Avocet Environmental Testing 1500 North State Street Bellingham, WA 98225

				(360) 733-1205	(360) 734-9033
	Total N, TKN, total P, nitrate	Laboratory	48 hours	Exact Scientific Services 3929 Spur Ridge Lane, Suite 1 Bellingham, WA 98226 (360) 733-1205	Avocet Environmental Testing 1500 North State Street Bellingham, WA 98225 (360) 734-9033
	DO, temperature, conductivity, nitrate, ammonium-N	In-Situ - YSI Pro Plus Meter, SOP	Immediate	NA	Exact Scientific Services 3929 Spur Ridge Lane, Suite 1 Bellingham, WA 98226 (360) 733-1205
	pH	In-situ pH Probe	Immediate	NA	Exact Scientific Services 3929 Spur Ridge Lane, Suite 1 Bellingham, WA 98226 (360) 733-1205
Ground/Soil Water	Total N, TKN, total P, nitrate	Laboratory	48 hours	Exact Scientific Services 3929 Spur Ridge Lane, Suite 1 Bellingham, WA 98226 (360) 733-1205	Avocet Environmental Testing 1500 North State Street Bellingham, WA 98225 (360) 734-9033
	DO, temperature, conductivity, nitrate, ammonium-N	In-Situ - YSI Pro Plus Meter, SOP	Immediate	NA	Exact Scientific Services 3929 Spur Ridge Lane, Suite 1 Bellingham, WA 98226 (360) 733-1205
	pH	In-situ pH Probe	Immediate	NA	Exact Scientific Services 3929 Spur Ridge Lane, Suite 1 Bellingham, WA 98226 (360) 733-1205
	Soil Moisture	In-Situ - Gypsum Block, SOP	Immediate	NA	NA
Air	Ammonia	In-Situ - Pranalytica, SOP	Immediate	NA	NA
	Methane, nitrous oxide, carbon dioxide	Laboratory		Agririculture and Agr-Food Canada Research Laboratory 6947 Highway 7 PO Box 1000 Agassiz, British Columbia V0M 1A0 604-796-2221	NA
Soil	EC, OM, FC, total N, nitrate, total P, pH	Laboratory	48 hours	Custom Dairy Services 8895 Guide Meridian Rd Lynden, WA 98264-9747 (360) 354-4344	Exact Scientific Services 3929 Spur Ridge Lane, Suite 1 Bellingham, WA 98226 (360) 733-1205

Commented [j65]: List each analyte on a separate line the ACTUAL testing method for lab work in the appropriate column (not the SOP). Applies to all lab analyses.

Manure	EC, OM, C:N, FC, total N, ammonium, nitrate, total P, pH	Laboratory	48 hours	Custom Dairy Services 8895 Guide Meridian Rd Lynden, WA 98264-9747 (360) 354-4344	Exact Scientific Services 3929 Spur Ridge Lane, Suite 1 Bellingham, WA 98226 (360) 733-1205
Forage	DM, CP (N), P, nitrate	Laboratory	72 hours	Custom Dairy Services 8895 Guide Meridian Rd Lynden, WA 98264-9747 (360) 354-4344	Edge Analytical, Inc. 805 West Orchard #4 Bellingham, WA 98225 (360) 715-1212

** See Table 7.1 for individual analytical methods for each analyte*

13.2. Corrective Actions

If problems with analysis at a laboratory arise, it will be foremost up to the lab manager to correct the issue appropriately. If not corrected, the samples will be sent to the secondary lab outlined in Table 13.1. If field equipment is not working, the sample will collected and sent to the laboratory listed for analysis.

14. QUALITY CONTROL

In order to identify any variability in sample collection, analysis, or measurement activity, a quality control protocol will be in place. Variability will be tested for in-field (collection) and laboratory (analysis) procedures. A combination of blanks, repeated measures, and duplicates for all analytes and mediums measured will help measure the effect of errors and identify areas where corrective action should be taken.

The laboratories used in the study follow- analytical method criteria and conduct their own in-house quality control procedures to ensure their methods and equipment are accurate and unbiased and that the data provided are of good quality. If at any time we feel that the primary laboratory is yielding questionable results, or we are having a quality issue with the lab, duplicate samples will be sent to the secondary lab for QC validation (see Table 13.1 for primary and secondary labs).

14.1. Blanks

Field blanks will be taken to assess the background or contamination levels (variability) of various parameters such as sample containers, handling procedures, and background pollution levels.

Field blanks will represent 2% of all samples (1 per 50 samples) taken for water quality parameters. A sample container will be filled with the same clean water used to rinse all equipment and bottles, handled in the same environment and the same way as sample containers and sent to the lab for analysis of the same analytes as the sample it is paired with.

Field blanks for air quality measures will be taken to assess background (ambient) concentration and handling procedures. For ammonia, a period of ambient sampling at approximately 24 in above the soil surface will precede each sampling event. For greenhouse gases, a sample of ambient air will be taken at the same time as each sampling event.

14.2. Repeated Measures

Repeated measures (replicate and/or split samples) will be conducted to assess the imprecision (random error) of in-situ field equipment and methods, sample collection and composite sampling methods, as well as to check the accuracy of laboratory analysis.

A replicate sample of surface water, ground water, soil, and manure will be taken every 20th sample (5% of total samples). The replicate will be taken at the same time as the primary sample and sent to the lab for duplicate analysis. For soil and manure samples, the duplicate will come from the same bucket as the primary sample, both of which are sub-samples from a composite of multiple samples.

Water samples measured in-situ with the field sampler will be split every 10th sample (10% of total samples) and analyzed in the same way, cleaning the probe between samples. Values will be recorded in the field log book.

A difference of up to 10% will be accepted between samples (%Diff = (|sample 1 – sample 2|)/[(sample 1 + sample 2)/2] * 100%). If the samples differ by more than 10%, corrective action will be taken (see Table 14.1).

Commented [j66]: 10% RPD is a very narrow range. Samples with significant matrix issues like manure and soils may not achieve this. I recommend 20% minimum, unless you have reason to believe this will not be an issue. What will happen if the RPD is above range?

14.3. Accuracy (Precision & Bias)

Accuracy of field equipment will be assed by in-field comparison to known values (i.e., known solutions, certified equipment values, etc.).

To measure the in-situ precision of the YSI field monitor, temperature, nitrate, and pH will be compared against known solutions or certified equipment every 10th sample. The pH probe will be verified with a known solution of pH 7.0. The nitrate probe will be validated against a 1 mg/L calibration solution. For temperature, a NIST certified thermometer will be inserted into the sample and compared against the instrument reading. Comparisons will be recorded in the field log book. Corrective action will be taken if any significant differences (Diff >10%) between the two methods are noted.

Commented [j67]: I noticed that nitrate will be analyzed in the field and lab. Will this be for the same sample location? Do you plan to compare these values or use it as a secondary check of the equipment?

Commented [j68]: Also – Note ammonia will only be measured in the field. May be a good idea to verify the results with some split lab analyses. Ammonia is well known to have significant matrix interferences, which is why a distillation is required prior to all analyses in the lab. I suggest splits so that you can verify interferences are not effecting the results measured in the field.

The temperature of the sample transport container (cooler) will be checked with a certified thermometer at each sample event. Temperature will be recorded in the field log book. Corrective action will be taken if the temperature is not at the specified level.

Table 14.1. Field sampling and analytical quality control parameters

Commented [j69]: What about rinsates? Any checks on contamination between sampling sites?

Commented [j70]: List quantifiable criteria where appropriate. (i.e. RPD</= 20%)

Field QC	Analyte (Matrix)	Frequency	Method/SOP Acceptance Limits	Corrective Action	Person(s) Responsible for CA	Data Quality Indicator (DQI)	Measurement Quality Objectives
Field Blanks	Surface Water	1 per 50 samples (2%)	SOP No false negatives or positives	New containers, new sample water, resample, or qualify data	Field personnel (in-situ), Project Manager (lab)	Field and laboratory precision, bias, variability	No false negatives or positives

	Ground water	1 per 50 samples (2%)	SOP No false negatives or positives	New containers, new sample water, resample, or qualify data	Field personnel (in-situ), Project Manager (lab)	Field and laboratory precision, bias, variability	No false negatives or positives
	Ammonia	1 for each sample	SOP No false negatives or positives	Subtract from sample value	Field personnel	Sample and background variability	No false negatives or positives
	GHG	1 per sample event	SOP No false negatives or positives	New syringes and/or vacutainers, subtract from sample value	Field personnel	Field and laboratory precision, bias, variability	No false negatives or positives
Field Replicate	Surface Water	1 per 20 samples (5%)	SOP Within specified precision limits (RPD)	Reclean, retest, SOP review, qualify data	Project Manager	Field and laboratory precision	Relative percent difference (RPD) (<10%)
	Ground water	1 per 20 samples (5%)	SOP Within specified precision limits (RPD)	Reclean, retest, SOP review, qualify data	Project Manager	Field and laboratory precision	Relative percent difference (<10%)
	Soil	1 per 20 samples (5%)	SOP Within specified precision limits (RPD)	Reclean, retest, SOP review, qualify data	Project Manager	Field and laboratory precision	Relative percent difference (<10%)
	Manure	1 per 20 samples (5%)	SOP Within specified precision limits (RPD)	Reclean, retest, SOP review, qualify data	Project Manager	Field and laboratory precision	Relative percent difference (<10%)
	GHG	1 per sample event	SOP Within specified precision limits (RPD)	SOP review, new syringes and vacutainers	Project Manager	Field and laboratory precision	Relative percent difference (<10%)
Field Splits	Water (surface and ground)	1 per 10 samples (10%)	SOP Within specified precision limits (RPD)	Check monitor batteries, recalibrate field equipment	Field personnel	Equipment precision and accuracy	Relative percent difference (<10%)
Cooler Temp	Temp	Every sample event	Within in specified range	Adjust ice content of cooler (+/-)	Field personnel	Variability	Within specified limits (3-5°C)

Commented [j71]: Duplicate? Or are you taking some locations in triplicate?

14.4 Laboratory Quality Control Procedures

The laboratory performs their own in-house QC to ensure that the quality of their data is good as well as to identify and corrective action that needs to be taken in response to identified deficiencies. The internal QC checks may differ slightly for each individual procedure, but in general include the following (information obtained from Exact Scientific Services, Inc):

Method Blanks - performed at a frequency of one per batch of samples per matrix type per sample extraction or preparation test method. The results of these samples are used to determine batch acceptance.

Laboratory Control Sample (QC Check Sample) - are analyzed at a minimum of 1 per batch of 20 or fewer samples per matrix type per sample extraction or preparation method except for analytes for which spiking solutions are not available such as total suspended solids, total dissolved solids, total volatile solids, total solids, pH, color, odor, temperature, dissolved oxygen or turbidity. The results of these samples are used to determine batch acceptance.

Matrix Spikes (MS) - are performed at a frequency of one in 20 samples per matrix type per sample extraction or preparation method except for analytes for which spiking solutions are not available such as, total suspended solids, total dissolved solids, total volatile solids, total solids, pH, color, odor, temperature, dissolved oxygen or turbidity. The sample(s) selected for spiking are rotated among received samples so that various matrix problems may be noted and/or addressed. Poor performance in a matrix spike generally indicates a problem with the sample composition, and not the laboratory analysis, and is reported to assist in data assessment.

Surrogates - Surrogate compounds are added to all samples, standards, and blanks for all organic chromatography test methods except when the matrix precludes its use or when a surrogate is not available. Poor surrogate recovery generally indicates a problem with the sample composition and is reported to assist in data assessment.

Matrix Spike Duplicates (MSDs) or Laboratory Duplicates - are analyzed at a minimum of 1 in 20 samples per matrix type per sample extraction or preparation test method. The selected sample(s) are rotated among received samples so that various matrix problems may be noted and/or addressed. Poor performance in the duplicates generally indicates a problem with the sample composition and is reported to assist in data assessment.

Commented [j72]: See earlier notes regarding QC – method dependent, then lab SOPs. Overall, it must meet QAPP DQOs so the specific, quantifiable limits must be listed somewhere in the QAPP for QC, reporting limits, and methods.

Commented [j73]: Note that usually in a commercial lab, you need to pay extra to guarantee your sample is the one chosen for MS/MSD. Otherwise it is an sample in the analytical batch of 20, which could contain other projects.

15. INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Proper testing, inspection, and maintenance of equipment will help mitigate any equipment issues and keep it in proper working order, thus reducing field error and possible sampling failures. The following is an explanation of the testing, inspection, and maintenance procedures for project equipment. Table 15.1 summarizes all these actions.

15.1. Inspection and Testing of Equipment

Inspection and testing of equipment will be conducted on a regular basis to ensure proper functioning and accuracy. Corrective action will be taken as appropriate to the concern at hand.

All equipment, including the YSI Professional Plus meter, pH meter, Nitrolux-S ammonia analyzer, soil moisture meter, thermometer, and Kestrel weather station, will be inspected up to 72 hours prior to a sampling event. Gypsum blocks will be inspected once yearly (September) in the field. Inspection results will be recorded into a log book. Any corrective action will be taken as necessary.

15.2. Maintenance of Equipment

All equipment will be maintained as outlined by manufactures recommendations. When available, repair kits will be kept on hand so that equipment, probes, etc., can be repaired as quickly as possible to minimize down time.

Table 15.1. Equipment maintenance, testing, and inspection activity procedures

Equipment/ Instrument	Maintenance Activity	Testing Activity	Inspection Activity	Responsible Person	Freq.	Acceptance Criteria	Corrective Action
YSI Pro Plus Field Meter	Check cleanliness and batteries	Check batteries, test probes to standards, calibrate	Check DO membrane, and probe connections	Field Team Leader, Project Manager	Every sampling day	No debris on probes, battery >30%, each probe within specified resolution of standard	Change batteries, membrane, or clean probes as needed, calibrate, or send back to company
YSI pH Meter	Check cleanliness and batteries	Check batteries, calibrate	Check probe and connections	Field Team Leader, Project Manager	Every sampling day	Battery >30%, within 0.01 units of standard	Change batteries, clean probe, calibrate, or send back to company
Watermark Soil Moisture Meter	Check batteries	Check batteries, calibrate	Check readings	Field Team Leader, Project Manager	Every sampling day	Battery >30%, within resolution at saturation	Change batteries, send back to manufacturer
Gypsum Blocks	Check material % (lifespan), check leads	Check proper functioning of block	Dig up once yearly to inspect gypsum level	Field Team Leader, Project Manager	Every sampling day (leads), September (block)	More than 40% in tact	Replace block
NIST Thermo-meter	Check for cracks in shaft	Make sure it is reading	Check for cracks	Field Team Leader, Project Manager	Every sampling day	No cracks	If cracked, replace
Nitrolux-S Ammonia Analyzer	Clean, charge batteries	Run internal calibration	Check hoses, couplings, and ports	Field Team Leader, Project Manager	Every sampling day	Within internal calibration limits	Charge, clean, or send back to manufacturer
Kestrel 4000 Weather Station	Check batteries	Check battery life, calibrate sensors	Check station parts for cracks and tension	Field Team Leader, Project Manager	Every sampling period	Battery >30%	Change batteries, or send back to manufacturer

16. INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

All field equipment will be calibrated on a regular basis and/or according to manufacture recommendations to ensure proper functioning and accuracy (Table 16.1). Equipment will be calibrated against known standards or NIST certified instruments. Calibration standards (pH 4, 7, & 10; nitrate 1 & 100 mg/L; ammonium 1 & 100 mg/L) will be kept on hand to ensure timely calibration procedures are followed. All calibration will be done by trained personnel following standard procedures and recorded in a log book. The project manager will periodically check all calibration documentation to ensure it is being done on schedule and that any identified errors have been noted and addressed.

16.1. Field Calibration

Field equipment will be calibrated prior to going out into the field for sampling events (see Table 16.1.). If any of the field equipment fails a field QC check, field equipment will be recalibrated and measures will be run again.

16.2. Calibration Standards

Certified NIST calibration standards and instruments will be used for calibration of field equipment. Certified calibration standards (pH, nitrate, conductivity, nitrate, and ammonium) will be purchased from the same company supplying the field monitor (YSI). Equipment will be calibrated on a one, two or three point scale. In-field spot checks will be done with a one point calibration. Comprehensive calibration checks will be done with a three point calibration (2 for pH) for more accurate calibration.

An NIST certified thermometer will be used to calibrate temperature readings from the field meter and weather station, as well as measure the transport cooler temperature.

Table 16.1. Equipment and instrument calibration procedures

Equipment/ Instrument	Probe/Model	Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible
YSI Professional Plus Meter	**DO**	2 to 3 point calibration to known standards	Before every sampling event	0.01 mg/L	Clean, recalibrate, or send back to manufacturer	Field Team Leader, Project Manager
	Temperature	Calibrate to NIST certified thermometer	Twice per year	0.1 °C	Clean, recalibrate, or send back to manufacturer	Field Team Leader, Project Manager
	Conductivity	1 point calibration to known standards	Before every sampling event	0.001 or 0.1 mS/cm	Clean, recalibrate, or send back to manufacturer	Field Team Leader, Project Manager
	Ammonium	2 point calibration to known standards	Before every sampling event	0.01 mg/L-N	Clean, recalibrate, or send back to manufacturer	Field Team Leader, Project Manager

	Nitrate	2 point calibration to known standards	Before every sampling event	0.01 mg/L-N	Clean, recalibrate, or send back to manufacturer	Field Team Leader, Project Manager
YSI pH Meter	**YSI pH10 Meter**	3 point calibration to known standards	Before every sampling event	0.1 units	Clean, recalibrate, or replace pH sensor	Field Team Leader, Project Manager
Soil Moisture Meter	**Watermark**	Calibrate to 0 and 100% saturation	Every 4 months (Jan, Apr, July, Oct)	Within 10% error	Recalibrate, check leads, send back to manufacturer	Field Team Leader, Project Manager
Gypsum Blocks	**Watermark**	Calibrate to 0 and 100% saturation	Before installation	Within 5% error	Replace	Field Team Leader, Project Manager
Ammonia Analyzer	**Nitrolux-S**	Manufacture calibration	Once per year	NA	NA	Project Manager, Manufacturer
Weather Station	**Kestral 4000**	Calibrate RH to standards, & temperature to NIST thermo.	Every 4 months (Jan, Apr, July, Oct)	Within 5% error	Recalibrate, send back to manufacturer	Field Team Leader, Project Manager

16.3. Laboratory Calibration

The laboratories used perform their own calibration procedures at set frequencies (SOP available upon request). All equipment and instruments used for measurement and analysis are traceable to NIST standards of measurement. All calibrations are dated and recorded for each instrument and are available for review upon request.

Commented [j74]: According to the requirements specified in the analytical method and in the labortory's SOP.

Commented [j75]: Not true. Are you referring to standards?

17. INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Most of the supplies and consumables utilized by the project are not "critical" for the project. The supplies that are critical to the project are all sample containers, calibration standards, and wash water.

To ensure that sample containers are sterile and of appropriate material for collection and analysis, all sample containers will be supplied by the analyzing laboratory. Calibration standards will be purchased from a company that can certify the reference standards that will be used for calibrating field equipment. In this case, we will purchase standards (pH, nitrate, conductivity, and ammonium) from the same company supplying the field monitor (YSI). Wash water will be deionized (DI) water purchased in sealed gallon jugs. All of these supplies will be kept on hand and repurchased before they get low. When available, certificates and testing records will be kept by the Project Manager.

Commented [j76]: Are you going to have any second-source check solutions for field equipment to verify the calibrations?

All supplies will be checked for acceptable parameters so that they meet project needs and capabilities. Supplies that do not met project needs, or are damaged, will be returned and an alternative found.

All project supplies and consumables will be checked by the Project Manager on a monthly basis to ensure appropriate quantities are always on hand. A detailed list of products, supplier

(vendor), and minimum quantity to be kept on hand will be compiled and checked on a monthly basis. All supplies will be stored on site at WCD.

18. NON-DIRECT MEASUREMENTS

Current and historical data on various water quality standards (fecal coliform, DO, temperature, conductivity, turbidity, and salinity) measured at specific sites within the watersheds (information available upon request) will be utilized by the project for identifying trends, areas of concern, and locations to target mitigation within the watersheds. The water quality data is provided monthly or bi-monthly by DOE and WIRA 1. All measurements and analysis are conducted by the Northwest Indian College (NWIC). Quality assurance plan and SOP are available from NWIC upon request.

Commented [j77]: Are you using exactly the same analytical methods as NWIC for lab analyses? (comparability)

To establish background values for risk estimates, scientific values from peer reviewed literature articles may be utilized. Any values used will be checked for validity and referenced appropriately.

Meteorological data from weather stations listed in Table 10.2 will be recorded and utilized to compare against our measured field data, as well as utilized by the ARM worksheet to forecast precipitation events. Trends in predicted and actual precipitation events will be recorded and analyzed for correlation for predictive and weighted (accuracy) purposes. Correlations between measures will be analyzed to determine which sites are most accurate and appropriate to utilize for certain areas throughout the County.

19. DATA MANAGEMENT

The proper management of data throughout the project lifecycle is crucial to the success of the project. This section details the data management process for data recording (logbook and instrument logger), verification and validation, transmittal, analysis, database transfer, management, and storage.

19.1. Data Collection, Entry, and Storage

Two types of data will be produced in the field, written data and logged data. All quantitative written data collected in the field (pH, soil temperature, soil moisture, thermometer temperature, QC checks, notes) will be recorded in a bound notebook following guidelines in section 12. This data will then be entered into the appropriate Excel spreadsheet within one week of the sampling event. Data logged by field equipment (multi-meter, ammonia analyzer, meteorological, GPS) will be downloaded using the appropriate technology and transferred to Excel within one week of data collection. Even though field equipment is able to log data, secondary written notes will be taken as a backup measure. All data will be checked by the project manager for error, outliers, or other abnormalities. Where appropriate, qualitative data (notes) recoded in the field will be entered into the appropriate spreadsheet. More often, this information will be used to assess abnormal data, trends, and relationships.

All analytical results obtained from the laboratories for field samples (water, soil, manure, forage, air), will be entered into the appropriate spreadsheet upon receipt from the laboratory. A hardcopy of all results will be retained by the Project Manager in a single binder. The lab also retains copies of all lab results in an online database which can be accessed by the Project Manager at any time.

All data will be managed by the Project Manager and/or the Data Manager. The data manager will store the data on WCD's secure server. Monthly backups and/or hardcopies of all data files will be kept in a secure off-site location in case of damage to the server. Per EPAs request, appropriate data will be transferred and stored on STORET by the Data Manager. Per EPA: "STORET (short for STOrage and RETrieval) Data Warehouse is an online repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and others".

19.2. Data Control and Verification

All data recorded and transferred to Excel or any other storage program is subject to quality control. Data sets will be verified by a second pair of eyes to ensure they are entered correctly.

Once all data is entered into Excel, it will be statistically analyzed in Excel for number, ranges, means, medians, standard deviations, and minimum and maximum values, as well as in SAS (SAS Institute., Cary, NC) using the appropriate statistical model. If appropriate, outliers will be identified and corrective action taken, if necessary, specific data sets will be transformed based on distribution and regression relationships, or other appropriate data processing tasks will be conducted. Comparison of data sets from each sample trial will be conducted on a temporal and spatial scale within and between test farms. Once appropriately analyzed and verified, data will be complied and reported.

20. ASSESSMENTS AND RESPONSE ACTIONS

Regular assessment of project activities, deliverables, and tools will be conducted to ensure that timelines are followed and outcomes achieved (see Table 20.1).

20.1. Assessment of Project Activities

All project activities will be audited on a monthly basis by the Project Manager to make sure that proper protocols are being followed for sample collection, handling, documentation, sample chain-of-custody, equipment checks and calibrations, and reporting. A quarterly review of all calibration records, field logs, laboratory results, and other documentation records will be conducted for completeness. Corrective action and follow up audits will be conducted if and when necessary.

20.2. Data Quality Assessments

Assessments of data quality will be conducted throughout the project by the Project Manager. Quality will be assessed based on results from calibrations, QA samples and tests, field documentation, statistical assessment (see 19.2.), and data review. Any areas of poor quality, based on set criteria, will be evaluated and corrected.

20.3. Project Deliverables

Project timelines will be reviewed on a monthly basis to make sure goals and deliverables are being met. If any severe deficits in time or activities are noted, corrective action will be taken, included reevaluation of project timelines, more project management or oversight, delegation of tasks, or restructuring of personal schedules.

Commented [j78]: Anticipated QAPP addendums and updates

20.4. Response Actions

The response action taken for correction of any project issues will be the responsibility of the Project Manager and/or the Project Oversight position. If corrective action is outside of the roles of WCD personnel, the EPA project office will be consulted.

Table 20.1. Project assessment activities, frequency, and responsible party

Assessment Type	Frequency	Person Performing Assessment	Person Monitoring Corrective Action
Field Sampling	Monthly	Project Manager	Project Manager
Analytical Data	Monthly	Project Manager	Project Manager
Laboratory Procedures	Per laboratory	Laboratory Manager	Laboratory Manager
Data Quality	Quarterly	Project Manager	Project Manager
Data Storage	Bi-annual	Data Manager	Project Manager
Project timelines and deliverables	Monthly	Project Manager	Project Manager
Records	Quarterly	Project Manager	Project Manager

21. REPORTS TO MANAGEMENT

Reporting is a necessary part of the project in order to assess progress and keep the granting agency (EPA) informed of project activities. Both quarterly financial and bi-annual project reports will be compiled and sent to the granting agency starting in 2010. Project reports, prepared by the Project Manager, are due at the beginning of January and July, and the final project report is due June 30, 2014. Included in progress reports will be a summary of data quality and quality assurance activities, corrective action taken for any significant project activity, and the project status as related to activity timelines.

22. DATA REVIEW, VERIFICATION, VALIDATION

This section lists the criteria for data review, verification, and validation to ensure that project data is of good quality.

22.1. Data Review

Data review is the process by which all data is reviewed by project personnel (Field or Project Manager) to ensure that data have been recorded, transmitted, and processed correctly. All data and notes collected in the field will be reviewed for completeness and accuracy by the Project

Manager on a regular basis following each sampling event. Sample results received from the laboratory will also be reviewed for discrepancies. All calibration and QA samples will be assessed to make sure they have been conducted according to schedule and that there are no significant results that were not properly corrected.

All data transmitted to Excel will be reviewed for accuracy by the Project Manager after each entry event. All calculations or transformations conducted within Excel will be reviewed by the Project Manager.

In addition to data, experimental design and sample number review will be conducted after year one to see if modifications or more stringent sampling protocols need to be added. Any revisions will be written up and a new QAPP will be submitted for review and approval.

22.2. Data Verification

Data verification is the process by which data is evaluated for completeness, correctness, and conformance. Following data review to ensure data have been entered correctly, data will undergo a verification process whereby outliers, missing data, or incomplete data will be identified and corrected as appropriate.

22.3. Data Validation

Data validation is the process by which the quality of a specific data set is determined relative to its end use. If any data set deviates from the QAPP, the Project Manager, project QA person, and EPA QA person will be consulted for validity and corrective action of the data set.

23. VERIFICATION AND VALIDATION METHODS

Data verification and validation will be performed by review of data completeness, calibration results, QA sample results, chain-of-custody forms, and statistical analysis. Verification will be conducted on data recording and transfer, data calculations, transformations, sorting, assessment of outliers, and qualification of data. Many of the procedures for conducting these reviews have been covered throughout this plan.

Data entry and verification will be conducted by the field personnel, Field Manager, Project Manager, or Data Manager. The Project Manager will review all data verification and validation reports to see if there have been any errors or deviations from the QAPP. The Project Manager will report to the Project or EPA QA Officer if corrective action needs to be taken.

24. RECONCILIATION WITH USER REQUIREMENTS

This section of the plan describes how the validated data will be evaluated to see if it meets project quality objectives (measurement and data quality). Under a systematic planning approach, EPA recommends that projects use the five Data Quality Assessment (DQA) process steps to evaluate how well the validated data supports the intended use. Those five steps are outlined below.

24.1. Review the Data Quality Objectives and Sampling Design

The data quality objectives (DQO) outlined in Section 7 will be reviewed on an annual basis by the Project Manager to assure that they are still applicable. Any revision to DQOs will be made by the Project Manager and be consistent with QAPP objectives. Similarly, sampling designs will be assessed after an adequate amount of data has been collected to assess variability of data and sample number estimations. Sample design revisions, although not expected, will be made when appropriate to best meet the needs of the project objectives while minimizing error.

Commented [j79]: And documented in an approved QAPP addendum.

Commented [j80]: And documented in an approved QAPP addendum.

24.2. Conduct a Preliminary Data Review

A preliminary data review will be conducted quarterly after each seasonal data collection period. Preliminary data review will consist of basic statistical analysis to identify normality, bias, outliers, anomalies, correlations, relationships, patterns, and insufficient data sets. This data review will aid in refining data collection techniques, modifying sample numbers, identifying relationships, and teasing out data set transformation when necessary.

If it is determined that a data set is below the acceptable sample variability (CV < 10%), sample frequency may be assessed to see if resources can be refocused to areas of the study that may require more frequent sampling to achieve the desired CV.

24.3. Select the Statistical Test

The statistical tests used for identifying relationships between and within data sets, as well as significant and error may vary for each analyte and variable. Choosing a statistical test will be based on the variability and distribution of the data, as well as the acceptable error and objective of the data set. Overall, all data sets will be analyzed for significance at an alpha of 0.05.

24.4. Verify the Assumptions of the Statistical Test

Verification of the assumptions of the statistical test chosen will assess whether the underlying assumptions are valid or whether departures from the test are acceptable. This assumption will be based on the amount of data available and may vary over time after more data has accumulated.

24.5. Draw Conclusions from the Data

After data has been reviewed and verified, it will be analyzed using the appropriate statistical test identified in step 3. Once analyzed, conclusions will be drawn and presented. Data will be presented in text, tables, and figures as appropriate for the data set and relationships being assessed. Conclusions should support project objectives and hypothesis testing.

If limitations of a data set (i.e., missing data, unusable data, etc.) are discovered during analysis, it will be reported as such. If data quality indicators do not meet performance criteria, sample design or analysis will be adjusted when possible. All adjustments made by the Project Manager will be verified with QA Managers.

Commented [j81]: Your references will be added, correct?